BULLETIN 405 JUNE, 1927

An Experimental Study of SWEET CLOVER

C. J. Willard

OHIO
AGRICULTURAL EXPERIMENT STATION
Wooster, Ohio

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PREFACE

This paper includes the results of experiments and observations on sweet clover, *Melilotus sp.*, at the Ohio State University during the years 1921 to 1925. The writer has received the cordial cooperation of many persons in carrying out these experiments. He is particularly indebted to Dr. E. N. Transeau, under whose direction they were carried out; to Dean Alfred Vivian, Dr. J. B. Park, and Mr. R. M. Salter for continued encouragement and assistance with the investigation; to Dr. J. F. Lyman for analyses made under his direction in the Department of Agricultural Chemistry, Ohio State University; to Mr. H. L. Borst for constant interested cooperation in the field work; to Mr. C. F. Monroe and Mr. R. W. Gerdel for making analyses; and to Dr. A. L. Whiting, Mr. T. E. Richmond, and Mr. H. J. Snider for suggestions and unpublished data.

AN EXPERIMENTAL STUDY OF SWEET CLOVER*

C. J. WILLARD

There is no more remarkable chapter in American agricultural history than the recent rapid rise of sweet clover to an important position as an agricultural crop. Long known as a roadside plant, it was commonly considered a weed by most farmers of twenty years ago. One state included it in a list of noxious weeds to be eradicated wherever found.

Many early reports of the experiment stations mention brief trials of the plant, but nothing definite came of them. A few farmers here and there discovered its virtues and told others about them, so that fifteen years ago there were all over the corn belt, and especially in Kentucky and the "black belt" of Alabama and Mississippi, local areas in which sweet clover was known and valued.

The turning point in the agricultural history of sweet clover may be said to be marked by the publication in 1912 by the Ohio Agricultural Experiment Station of a comprehensive bulletin of nearly 100 pages by Lloyd (14)†, which brought together practically everything known about the crop at that date.

Since then there has been a continuously accelerated interest in sweet clover on the part of both farmers and experiment stations. In 1925, according to the best estimates available, between one and two million acres of sweet clover was grown in the United States. The agriculture of Wood, Henry, and Montgomery Counties in Ohio, and of larger areas in the states to the west and northwest has been literally transformed by the introduction of this crop in the rotations. It seems destined to continue its spread until it becomes at least the third most important legume in the United States. Already it is the second legume in Ohio in acreage sown, and in many areas of the country more sweet clover is grown than all other legumes combined.

The most important phase of the study here reported is the quantitative life history of the yield and composition of sweet clover at different stages of its growth as compared with other legumes, and when sown under different conditions. In connection with this fundamental life history study, experiments and observations were made on the rate, date, and method of seeding; the agricultural

*Received for publication June 1, 1926.
†Reference is by number to "Literature cited", page 82.

value of the varieties and species; the effect of cutting at various stages of growth; the ratio of tops to roots; the ratio of dry to green weight; the proportion of leaves in the tops; the distribution of roots in the soil; and the association of sweet clover with other plants.

METHODS OF EXPERIMENTATION

Soil types.—All of these experiments were conducted on the plots of the Department of Farm Crops of the Ohio State University. The soil on this tract is seriously lacking in uniformity. Two main soil types are represented: a light colored soil with acid surface soil containing little organic matter, mapped as Miami silt loam; and a dark colored soil containing considerable organic matter and only slightly acid in the top soil, mapped as Brookston silty clay loam. There are also a few spots of a particularly ashy gray soil, mapped as Crosby silt loam. All of these are underlain with calcareous drift at 28 to 30 inches. They are widely distributed typical soil types of western Ohio, the section of the State best adapted to sweet clover. The plots are thoroly tiled.

Method of securing data on the yield of roots.—Considerable experimenting in methods was carried on while securing the earlier yields, but the method finally adopted as standard was as follows:

An iron square, enclosing one square yard, similar to that described by Arny and Steinmetz (3), was made of quarter-inch wrought iron. This square had one removable side, and the ends of the two sides joining this removable side were turned up about two inches. This removable side was like an end-gate rod, with one pointed end which could be pushed thru the tangle of stems near the ground. A hole at each end of this piece could be slipped over the turned-up ends of the other part, thus forming a complete square. This iron could be placed in forage of any height as soon as one side was cleared. It was indispensable in laying out plots in plants over one foot tall, and useful at all times.

After the iron was in place, the tops, if large enough to interfere with harvesting, were cut with a sickle about as a mowing machine would do it. This part was recorded, when dry, as "hay". Low tops were left on the plant and cut from the roots after they were washed. A trench one foot deep and a foot or more wide, and extending beyond the iron at each end, was dug along one side of the square yard marked by the iron. The earth from the square-yard sample was broken into this trench in convenient chunks, cut to a depth of one foot. These chunks were broken up by hand and the roots shaken and picked out. The roots were washed thoroly, the tops, or stubble, clipped from them, and they were counted to give the number of plants per square yard.

Accuracy of the method.—Obviously this method did not secure the finest feeding roots. These could be secured only by washing the soil thru a sieve. The lack of running water on these plots made a washing method impracticable, and even if water had been at hand, it would have required far more labor than was available to wash out the number of samples reported here. However, these fine roots, tho of the utmost physiological importance, weigh surprisingly little. In connection with the first harvest of the deeper roots of sweet clover in July 1923, after the roots had been harvested in the usual way, two of us spent three hours in carefully picking over the soil and taking out every visible root. These fine roots when dried weighed only 5 grams, or 5.3 percent of the total weight. Since the average root in this plot weighed nearly 4 grams, two plants in or out of the square-yard sample would have influenced the weight more than the loss of these fine roots. While the weights of roots will average somewhat too low, by far the largest part of the roots were secured, and other sources of error are fully as important as this one.

Method of securing weights of samples.—The tops, stubble, and roots were placed in separate labeled muslin or cheesecloth cloths and dried by artificial heat, or when this was not available, allowed to dry on the cloth in an airy attic. As soon as dry the samples were stored in the laboratory where they remained until all from that series had been stored under uniform conditions for at least four weeks. They were then weighed on the same day or successive days, under as nearly identical conditions as possible.

Usually the weights were taken in a dry, heated laboratory after the heat had been on long enough to bring everything to a rather uniform moisture content of about 7 percent. In 1925, when some samples were necessarily weighed in the summer, the weights were corrected to this basis, so that all "air-dry" weights and percentages can, without serious error, be recalculated to a moisture-free basis by figuring that the samples contained 93 percent dry matter. This is considerably drier than hay in the average haymow, but, since all the weights are on the same basis, the difference is not of practical importance. The samples were weighed to the nearest gram on several types of scales. When one plant on the edge of a square-yard sample may influence the weight 2 or 3 grams, according to whether it is counted in or out of the plot, it is a useless refinement to weigh the sample to centigrams.

Method of selecting the square-yard sample.—Random sampling, or sampling according to a pre-arranged diagram (3), has usually been recommended for such work in order to avoid any possible prejudice on the part of the investigator. However, random sampling gives valuable and trustworthy results only when enough samples are taken to give a dependable average. It was physically impossible in this investigation to dig roots for this number of samples, as each square yard harvested represented an average of over two hours' work. It became obvious early in the work that far more accurate results would be secured if each sample were carefully selected for uniformity than if it were chosen at random.

Recently, the plan was adopted of laying out a succession of square yards at one time, when their uniformity can be rather readily judged. If a sufficient area is sown on non-uniform soil, it is thus possible to lay out fairly uniform small plots after the crop is well established and has indicated somewhat by its growth the extent and nature of the soil variations in the field. Experience has convinced the writer that this is the most accurate known method for obtaining reliable results from a relatively small number of samples on non-uniform soil. We are using it more and more extensively and with good results.

The absurd results that random sampling might lead to on these soil types are well illustrated by an extreme instance: on September 15, 1925, two samples of first-year sweet clover, obviously different but part of the same plot, were harvested less than a yard apart, one yielding at the rate of 1430 pounds of tops and 920 pounds of roots per acre, the other 480 pounds of tops and 320 pounds of roots. The good area here produced practically three times as much as the poor area. Yet, by selecting a series of uniform square yards, it was possible to secure trustworthy and valuable data from this plot.

Even tho the samples are carefully selected, replication is always necessary to secure reliable results. In this work as many replications were made as it was feasible to collect.

Probable error of a single determination.—The largest number of directly comparable samples taken at one time in this investigation was four. Probable errors of the individual averages reported would, therefore, be valuable only as a mathematical measure of the variations in that particular set of samples, and would not be worth the time required for calculating or the space for reporting them.

However, we have 54 averages of 2, 3, or 4 samples of sweet clover which were harvested on the same day under comparable conditions. From these it is possible by the method suggested by Hayes (10) to calculate the probable error of averages of 2, 3, or 4 samples.

This method consists in calculating the deviation of each determination from its mean, expressed in percent of the mean. The standard deviation of these percentage deviations is then calculated by the formula S. D.=square root of (D^2 divided by n), and the probable error of a single variate by the formula E sub s= .6745 S. D. The probable errors of averages of 2, 3, and 4 samples may then be found from the formula E sub m=E sub s divided by the square root of n.

The probable error of a single variate so calculated from the comparison of 178 single determinations with their means, is ±11.5 percent of the mean for the tops and ±11.3 percent of the mean for the roots. The probable errors of the averages reported in this investigation would be the following:

	Tops	Roots
	Percent	Percent
E_m for 2 samples	±8 2	±8 0
E_m for 3 samples	±6 7	±6 5
E_m for 4 samples	±5 8	±5 6

Number of places to which results were calculated.—It is perfectly clear from these probable errors that it is absurd to report results calculated to tenths of a pound per acre, as has sometimes been done, or even to units. While it appears that no place below the hundreds is really significant, in most instances, the yields have been reported to the nearest 10 pounds per acre.

Validity of final results.—While there is necessarily a large element of experimental error, this is further reduced by the fact that the samples were taken in series, so that each date is more or less of a check on the others. The writer believes that the general picture presented of the development of sweet clover in different seasons and under various treatments is an accurate one.

THE PLANTINGS MADE AND DATA SECURED

Cultural methods followed.—Spring seedings were always made in a nurse crop of Fulghum oats sown at 4 to 6 pecks per acre and allowed to mature for grain. Summer seedings were made alone. The seeds were sown with a disc grain drill, dropping the seed ahead of the discs. All of the plots received liberal applications of ground limestone and usually 300 pounds per acre of acid phosphate. The legumes were sown at 12 to 15 pounds per acre, except alsike clover, which was sown at 8 to 12 pounds. The seed bed was prepared as would be done under farm conditions.

Preliminary experiments were carried out in a series of plots sown in 1921, primarily to compare Hubam with three other strains of sweet clover. Some results from this series have already been reported (33). In 1922, starting late in April, four square-yard samples each week were harvested from this series. Much valuable information was secured, but since no analyses were made of the samples, the data are omitted. However, they support in every way the data secured in later years.

Series 1, sown spring 1922, April 6, was on a range which grades from dark soil at the west end to light soil at the east, the change occuring about the middle of Plot 11. The plots were 13 by 100 feet. The plan from west to east was as follows:

Plot 1. White sweet clover
Plot 2. Alfalfa
Plot 3. Yellow sweet clover
Plot 4. White sweet clover
Plot 5. Red clover
Plot 6. Alsike clover
Plot 7. White sweet clover
Plot 8. Hubam sweet clover
Plots 9 to 16 repeated the same crops in the same order

All the crops made excellent stands. There were good rains in August and September and there was so much hay on the plots that it was decided to find out what effect removing it would have on the next year's growth. Plots 8 to 16, inclusive, accordingly, were cut for hay on September 28. Shrinkage samples were taken; the final shrunken weights of hay are given in Table 1.

Plots 15 and 16 were injured by turning the binder on them when cutting the oats.

TABLE 1.—Series 1, Yields of Hay, September 28, 1922

Plot No.	Crop	Net yield, pounds per acre
8	Hubam	3,930
9	White sweet clover	2,570
10	Alfalfa	1,660
11	Yellow sweet clover	770
12	White sweet clover	1,870
13	Red clover	1,890
14	Alsike clover	760
15	White sweet clover	630
16	Hubam	1,310

Square-yard harvests of tops and roots were made September 6 and 28. The following year they were made on eight dates, approximately every two weeks from March 31 to August 8. The data secured are given in Table 3; for the Hubam data see Table 13. Cutting the fall growth for hay made such a tremendous difference in the growth of the sweet clover that it seems necessary to average the white sweet clover data in three parts; one averaging the three plots cut for hay in the fall, one the three plots not cut, and one combining the six plots. The alfalfa in this series was cut for hay on June 20 and July 31.

Series 2, sown summer 1922, was planned to compare sowing legumes alone in the summer with sowing them in the spring with a nurse crop. For this comparison square-yard harvests were made in several plots of a general forage crop experiment sown in the summer of 1922. White sweet clover, yellow sweet clover, mammoth clover, red clover, alsike clover, and common and Grimm alfalfas were the legumes studied. The soil was quite loose and dry when the seedings were made.

The alfalfa plots were the only ones on which the stands appeared satisfactory in the fall, tho the alsike was moderately good. The failure to secure good stands was evidently due, at least in part, to moisture conditions, since the stands were better where there was an increased moisture supply. The sweet clovers heaved badly during the winter, but they recovered well, and made a good growth in 1923.

The stands of red and mammoth clovers seemed so poor that no root harvests were made, but they yielded a crop of hay on June 20. The alfalfa was cut for hay on June 20, July 31, and September 20.

Series 3, sown spring 1923, was another comparison of sweet clover with other legumes. Most of the plots were ruined by volunteer sweet clover, and only a few harvests were secured (Table 5).

Series 4, sown summer 1923, was nearly a total failure, alfalfa and yellow sweet clover being the only exceptions. No square-yard harvests were made from this series of legumes.

Series 5, sown spring 1924.—In addition to a rate-of-seeding test of sweet clover and some miscellaneous plots, the series included the following crops and varieties:

1. White sweet clover
2. Pearson white sweet clover
3. Grundy Co. white sweet clover
4. Common yellow sweet clover
5. Albotrea yellow sweet clover
6. Hubam sweet clover
7. Common alfalfa
8. Grimm alfalfa
9. Red clover
10. Mammoth clover
11. Alsike clover

The spring was very moist, and excellent stands of all the crops were secured. The oats were cut July 21. There was practically no rain from July 10 until November, and the plants made very little top growth after oats were harvested. A series of square-yard harvests were made early in November to determine the final amount of material which went into the winter. The plots were baked so hard and the growth was so small that earlier harvests were not worth the labor involved.

In 1925 square-yard harvests were made in these plots about once a month. The spring was very dry and the growth short and poor. The data secured are given in Table 6. This series did not include any dark soil, and the red, alsike, and mammoth clovers, and one plot of sweet clover were on the particularly unfavorable ashy gray soil mapped as Crosby silt loam. This seemed to reduce the yield of the true clovers more than that of the sweet clover. The alfalfa was cut for hay on June 6, July 17, and September 9.

Series 6, sown spring 1924, was ordinary white sweet clover sown on another range, to provide material for various studies of the crop. One harvest was made before the oats were cut, on July 17, and another September 13. Successive square-yard plots were then laid out in four parts of the range. Four square yards were harvested every two weeks from October 4 to November 25 and every week from March 26 to July 25, 1925. Two of these successions of plots were entirely on light soil; one was on moderately dark soil; and one on typical dark soil. The data secured from these harvests are given in Table 7.

Series 7, sown spring 1924, consisted of seven plots, 16 by 16 feet, sown without a nurse crop. The crops included were white sweet clover, Grundy Co. white sweet clover, Pearson white sweet clover, yellow sweet clover, Albotrea yellow sweet clover, red clover, and mammoth clover. All the plots were sown by hand on April 10, at thick indefinite rates. Excellent stands resulted, but the crops would have been almost completely killed out by weeds if they had not been thoroly hand-weeded. The results secured are valuable in showing what sweet clover can produce under favorable conditions, but are not practical under our conditions. The data are given in Table 8.

Series 8, sown spring 1925, was an extensive series of plots, but the yields are omitted here because the second year's data are not available.

CHEMICAL ANALYSES OF SAMPLES

Since sweet clover is a legume, the greatest interest in its chemical composition centers in its nitrogen content. Determinations of nitrogen in most of the samples harvested in 1923, 1924, and 1925, were made in the Department of Agricultural Chemistry of the Ohio State University, under the direction of Dr. J. F. Lyman.

Mineral analyses of some of the samples were made by Mr. C. F. Monroe, assistant in Dairy Chemistry at the Ohio Agricultural Experiment Station, who wished to obtain information on the mineral content of sweet clover hay for use in his work. Mr. Monroe determined the nitrogen, total ash, calcium, magnesium, and phosphorus content of 22 of the most typical samples of tops and hay from this investigation (37). Arrangements were made later to have determinations of phosphorus, potassium, calcium, and magnesium in 54 samples made in the Department of Agricultural Chemistry of the Ohio State University. Potassium determinations in 8 samples of fall-cut hay and feeding-stuffs analyses of 13 samples were made by Mr. R. W. Gerdel, assistant in Agronomy at the Ohio Agricultural Experiment Station.

Since the analyses from these different sources supplement each other, it has seemed desirable to report them together in the tables, except for the feeding-stuffs analyses, which are given in Table 18.

Errors of sampling for analysis.—Samples collected in the same or adjacent plots on the same day are not necessarily identical in analysis. In these series of analyses enough duplicate samples were analyzed to gain a fair idea of the possible extent of variation between samples which should be identical.

In Series 1 and 2, nitrogen was determined in two samples on each date of harvesting. In Series 6, samples from two plots were analyzed thruout the series. The differences between analyses of these harvests on the same date give a measure of the possible range of variation in nitrogen content due to variation in field samples. The data from these replicated samples are given in Table 2. From this table, the probable error of a single variate was found by calculating the standard deviation of the entire number of pairs of analyses and applying the formula E sub s=.6745 S. D. Using this method instead of calculating the percentage deviation as suggested by Hayes (10), assumes that the numerical deviations of samples containing low percentages of nitrogen are as great as those of samples containing high percentages of nitrogen. This is manifestly not quite true, but the advantage of having a figure for probable error which is directly applicable to the percentages reported outweighs for this set of determinations this slight source of error.

TABLE 2.—Comparison of Nitrogen Determinations in Samples of White Sweet Clover Harvested on the Same Day

	Percentage of nitrogen in tops or hay			Percentage of nitrogen in roots		
Series 1	Plot 1	Plot 7	Average	Plot 1	Plot 7	Average
September 6, 1922	2.76	3.26	3.01	3.22	3.23	3.22
September 28, 1922	....	....	....	3.13	3.03	3.08
March 31, 1923	4.16	2.79	3.48	4.53	4.49	4.51
April 24, 1923	4.15	4 21	4.18	4.88	4.26	4.49
May 10, 1923	3.16	2.92	3.04	3.65	3.69	3.67
May 24, 1923	2.13	3.09	2.61	3.10	3.12	3.11
June 14, 1923	2.31	2.16	2.24	2.27	2.40	2.33
July 2, 1923	1.81	1.89	1.85	2.44	2.03	2.24
July 19, 1923	1.51	1.52	1.51	1.76	1.77	1.77
August 8, 1923	1.63	1.22	1.42	1.39	2.33	1.66
Series 2	Plot 4	Plot 21	Average	Plot 4	Plot 21	Average
April 12, 1923	4.68	4.33	4.50	4.49	4.51	4.50
May 1, 1923	4.68	4.38	4.53	2.52	2.40	2.46
May 19, 1923	3.05	3.58	3.32	1.94	1.95	1.95
June 2, 1923	2.62	2.94	2.78	1.57	1.50	1.54
June 23, 1923	2.73	2.00	2.37	1.10	1.01	1.06
July 12, 1923	1.78	1.79	1.79	1.22	1.23	1.23
July 30, 1923	1.47	1.51	1.49	1.18	1.08	1.13
Series 6	Plot 1	Plot 4	Average	Plot 1	Plot 4	Average
October 4, 1924	....	....	....	3.16	3.02	3.09
October 18, 1924	....	....	....	3.43	3.23	3.33
November 8, 1924	....	....	....	3.68	3.43	3.55
November 25, 1924	....	....	....	3.81	3.71	3.76
March 26, 1925	4.64	4.68	4.66	4.01	3.84	3.93
April 3, 1925	4.29	4.39	4.34	4.46	4.00	4.23
April 10, 1925	3.87	4.22	4.05	4.23	3.79	4.01
April 17, 1925	3.93	3.47	3.70	3.33	3.44	3.39
April 24, 1925	3.63	3.57	3.60	3.25	2.41	3.83
May 2, 1925	3.82	3.60	3.71	2.53	2.39	2.46
May 8, 1925	3.47	3.47	3.47	1.91	2.07	1.99
May 16, 1925	3.75	3.41	3.58	1.73	2.16	1.95
May 22, 1925	3.09	3.06	3.08	1.85	2.00	1.93
May 30, 1925	2.85	2.79	2.82	1.82	1.81	1.82
June 6, 1925	2.36	2.56	2.46	1.82	1.67	1.75
June 13, 1925	2.33	2.27	2.30	1.92	1.80	1.86
June 20, 1925	2.09	2.05	2.07	1.92	1.92	1.93
June 26, 1925	2.04	1.77	1.90	1.42	1.50	1.46
July 3, 1925	1.87	1.87	1.87	1.39	1.72	1.56
July 11, 1925	1.82	1.78	1.80	1.37	1.29	1.33
July 18, 1925	1.85	1.76	1.80	1.48	1.52	1.50
July 25, 1925	1.78	1.81	1.80	1.31	1.60	1.46

The probable error of a single determination so computed is ± 0.13 percent for the analyses of the tops and hay, and ± 0.10 percent for the analyses of the roots. The probable error of a difference is found by the formula E sub dif.=sq. rt. $(E^2+E^2_2)$. If we wish to compare two of these analyses, they have the same probable error, so that E sub dif.=sq. rt. ($2E^2$ sub s) or ± 0.18 and ± 0.14 for the tops and roots, respectively. If we accept the usual rule that a difference should be three times its probable error to be significant, a difference between analyses of two samples should be at least 0.54 percent for the tops or 0.42 percent for the roots in order to be significant. In Series 2 and 6 there was a definite soil-type difference between the two plots from which the samples were taken; but, unless perhaps in the roots in the fall of 1924, there does not seem to be any consistent variation due to soil type.

In the mineral analyses two samples of tops on September 6, 1922; four samples of roots on April 3, 1925; and four of hay on June 13, 1925, were analyzed to give some measure of the range of variation to be expected in the mineral analyses. These samples (Tables 9 and 10) show that there is also a considerable range in the mineral composition of samples harvested in the same field on the same date. The numbers are not sufficient for probable error calculations.

The analytical results.—All analyses were made and are reported on the air-dry basis. The samples were quite uniformly air-dry, as previously explained, and if analyses on the moisture-free basis are desired, the error in recalculating on the basis of 93 percent dry matter will be slight. The nitrogen determinations and the amounts of nitrogen per acre are given in Tables 3 to 8, inclusive. The mineral analyses are reported in Tables 9 to 12, inclusive.

In making out these tables, in order to calculate the total amount per acre of the various elements, it was necessary to estimate the composition of several of the samples, especially of stubble. This was done as carefully as possible from all available data. Unpublished data* of Whiting and Richmond were used in estimating the potassium in Series 7, Table 10. These estimated figures are indicated by an asterisk.

*These data have since been published in Soil Science 22:83-95, August, 1926.

TABLE 3.—Air-dry Yield, Percentage of Nitrogen and Amount of Nitrogen per Acre in Various Crops, Series 1, 1922-23

Crop and date	Pounds per acre				Percentage of nitrogen				Pounds nitrogen per acre					No. plants per sq. yd.	No. samples averaged
	Hay	Stubble	Tops	Roots	Hay	Stubble	Tops	Roots	Hay	Stubble	Tops	Roots	Total		
White sweet clover, Not cut for hay in 1922															
Sept. 6, 1922	......	......	1970	1400	......	......	3.01	3.22	......	......	59	45	104	73	3
Sept. 28, 1922	......	......	2360	2320	......	......	2.77	3.08	......	......	65	72	137	84	3
Mar. 31, 1923	......	......	430	3600	......	......	3.48	4.51	......	......	15	162	177	89	3
Apr. 24, 1923	......	......	1510	2300	......	......	4.18	4.49	......	......	63	103	166	88	3
May 10, 1923	......	......	4210	2030	......	......	3.04	3.67	......	......	128	75	203	93	3
May 24, 1923	......	......	5120	1810	......	......	2.61	3.11	......	......	134	56	190	52	3
June 14, 1923	5380	740	6120	1390	2.24	1.47	2.15	2.33	121	11	132	32	164	59	3
July 2, 1923	6890	780	7670	660	1.85	1.17	1.78	2.24	128	9	137	15	152	32	3
July 19, 1923	7160	1070	8230	780	1.51	1.05	1.45	1.77	108	11	119	14	133	28	3
Aug. 8, 1923	8860	1210	10070	820	1.42	.81	1.35	1.86	126	10	136	15	151	18	2
White sweet clover, Cut for hay in 1922															
Sept. 6, 1922	......	......	1150	920	......	......	*3.01	*3.22	......	......	35	30	65	90	4
Sept. 28, 1922	......	......	2620	1610	......	......	*2.77	*3.08	......	......	72	50	122	62	3
Apr. 7, 1823	......	......	290	1350	......	......	*3.48	*4.51	......	......	10	61	71	68†	3
Apr. 26, 1923	......	......	800	1210	......	......	*4.18	*4.49	......	......	34	54	88	70	3
May 17, 1923	......	......	2290	880	......	......	*3.04	*3.67	......	......	70	32	102	61	3
May 31, 1923	......	......	3840	950	......	......	*2.61	*3.11	......	......	100	30	130	43	3
June 16, 1923	4230	610	4840	860	*2.24	*1.47	*2.15	*2.33	95	9	104	20	124	49	3
July 7, 1922	6110	820	6930	710	*1.85	*1.17	*1.78	*2.24	113	10	123	16	139	36	3
July 20, 1923	7380	900	8280	760	*1.51	*1.05	*1.45	*1.77	111	10	121	13	134	32	3
														†2 plots	
White sweet clover, Half cut for hay, half not cut															
Sept. 6, 1922	......	......	1560	1160	......	......	3.01	3.22	......	......	47	37	84	82	7
Sept. 28, 1922	......	......	2490	1960	......	......	2.77	3.08	......	......	69	60	129	73	6
Mar. 31,—Apr. 7, 1923	......	......	360	2480	......	......	3.48	4.51	......	......	12	112	124	80†	6
Apr. 24—26, 1923	......	......	1150	1750	......	......	4.18	4.49	......	......	48	79	127	79	6
May 10—17, 1923	......	......	3250	1450	......	......	3.04	3.67	......	......	99	53	152	77	6
May 24—31, 1923	......	......	4480	1380	......	......	2.61	3.11	......	......	117	43	160	48	6
June 14—16, 1923	4800	680	5480	1120	2.24	1.47	2.15	2.33	108	10	118	26	144	54	6
July 2—7, 1923	6500	800	7300	690	1.85	1.17	1.78	2.24	120	10	130	15	145	34	6
July 19—20, 1923	7270	980	8250	770	1.51	1.05	1.45	1.77	110	10	120	14	134	30	6
														†5 plots	

TABLE 3.—Air-dry Yield, Percentage of Nitrogen and Amount of Nitrogen per Acre in Various Crops, Series 1, 1922-23—Continued

Crop and date	Pounds per acre				Percentage of nitrogen				Pounds nitrogen per acre					No. plants per sq. yd.	No. samples aver-aged
	Hay	Stubble	Tops	Roots	Hay	Stubble	Tops	Roots	Hay	Stubble	Tops	Roots	Total		
Yellow sweet clover															
Sept. 6, 1922	......	......	1790	2990	......	......	2.75	2.83	......	......	49	85	134	118	1
Sept. 28, 1922	......	......	1370	2460	......	......	3.25	2.88	......	......	45	71	116	85	3
Mar. 31—Apr. 7, 1923	......	......	330	2420	......	......	4.69	3.93	......	......	16	95	111	75	2
Apr. 24—26, 1923	......	......	1570	2080	......	......	4.23	3.98	......	......	66	83	149	143	2
May 10—17, 1923	......	......	4140	1740	......	......	3.44	2.44	......	......	142	43	185	200	2
May 24—31, 1923	......	......	4750	1450	......	......	3.24	2.37	......	......	154	34	188	80	2
June 14—16, 1923	4850	570	5420	920	2.47	1.65	2.38	2.24	120	9	129	21	150	61	2
July 2—7, 1923	4650	390	5040	380	1.61	1.51	1.60	2.19	75	6	81	8	89	24	2
Alfalfa															
Sept. 6, 1922	......	......	1050	750	......	......	2.91	2.00	......	......	31	15	46	110	2
Sept. 28, 1922	......	......	1700	1380	......	......	2.71	2.35	......	......	46	32	78	124	2
Mar. 31—Apr. 7, 1923	......	......	820	1250	......	......	4.42	3.23	......	......	36	41	77	133	2
Apr. 24—26, 1923	......	......	1510	1070	......	......	3.83	2.91	......	......	58	31	89	120	2
May 10—17, 1923	......	......	2910	1040	......	......	3.35	2.11	......	......	98	22	120	145	2
May 24—31, 1923	......	......	4570	1350	......	......	2.99	1.89	......	......	137	25	162	103	2
June 14—16, 1923	4320	550	4870	1410	2.22	1.86	2.18	2.23	96	10	106	31	137	116	2
July 2—7, 1923	1610	870	2480	1160	2.63	1.59	2.26	1.83	42	14	56	21	77	90	2
July 19—20, 1923	2830	850	3680	1300	2.51	1.39	2.30	1.82	71	12	83	24	107	213	2
Aug. 8, 1923	660	720	1380	1220	*3.50	1.75	2.59	1.91	23	13	36	23	59	92	2
Oct. 6, 1923	2200	840	3040	2380	2.66	2.43	2.59	2.08	59	20	79	49	128	94	2

TABLE 3.—Air-dry Yield, Percentage of Nitrogen and Amount of Nitrogen per Acre in Various Crops, Series 1, 1922-23—Concluded

Crop and date	Pounds per acre				Percentage of nitrogen				Pounds nitrogen per acre					No. plants per sq. yd.	No. samples averaged
	Hay	Stubble	Tops	Roots	Hay	Stubble	Tops	Roots	Hay	Stubble	Tops	Roots	Total		
Red clover															
Sept. 6, 1922	......	......	1070	330	......	......	*3.00	1.93	....	......	32	6	38	185	2
Sept. 28, 1922	......	......	1950	510	......	......	2.92	2.43	....	......	57	12	69	124	3
Mar. 31—Apr. 7, 1923	......	......	660	980	......	......	3.40	3.22	....	......	22	32	54	149	2
Apr. 24—26, 1923	......	......	1800	1050	......	......	3.16	2.43	....	......	57	26	83	195	2
May 10—17, 1923	......	......	3810	1410	......	......	2.52	1.97	......	......	96	28	124	211	2
May 24-31, 1923	......	......	5600	1250	......	......	2.89	2.01	......	......	162	25	187	186	2
June 14, 1923	3790	530	4320	1120	2.10	1.84	2.07	1.93	80	10	89	21	110	156	2
July 2—7, 1923	3900	680	4580	840	2.28	1.83	2.21	2.00	89	12	101	17	118	84	2
Alsike clover															
Sept. 6, 1922	......	......	1110	220	......	......	*3.00	1.97	......	......	33	4	37	75	2
Sept. 28, 1922	......	......	2280	600	......	......	2.61	2.57	......	......	60	15	75	75	2
Mar. 31—Apr. 7, 1923	......	......	1000	1320	......	......	3.56	3.08	......	......	36	41	77	123	2
Apr. 24—26, 1923	......	......	1900	1000	......	......	2.83	2.42	......	......	54	24	78	111	2
May 10—17, 1923	......	......	3310	1040	......	......	2.61	2.09	......	......	86	22	108	78	2
May 24—31, 1923	......	......	5650	1280	......	......	2.71	2.13	......	......	153	27	180	123	2
June 14—16, 1923	4500	680	5180	930	2.29	1.64	2.21	1.93	103	11	114	18	132	110	2
July 2—7, 1923	4080	400	4480	520	1.91	1.88	1.91	1.92	78	7	85	10	95	46	2

*Estimated.

TABLE 4.—Air-dry Yield, Percentage of Nitrogen and Amount of Nitrogen per Acre in Various Crops, Series 2, 1922-23

Crop and date	Pounds per acre				Percentage of nitrogen				Pounds of nitrogen per acre					Number plants per sq. yard	Number samples averaged
	Hay	Stubble	Tops	Roots	Hay	Stubble	Tops	Roots	Hay	Stubble	Tops	Roots	Total		
White sweet clover															
October 17, 1922	...	...	260	160	...	...	3.67	2.34	...	...	10	4	14	57	1
April 12, 1923	...	...	140	540	...	...	4.50	4.50	...	...	6	24	31	95	2
May 1, 1923	...	...	630	370	...	...	4.53	2.46	...	...	29	9	38	83	2
May 19, 1923	...	...	1,850	500	...	...	3.32	1.95	...	...	61	10	71	98	2
June 2, 1923	...	...	3,710	520	...	...	2.78	1.54	...	...	103	8	111	88	2
June 23, 1923	5,680	710	6,390	660	2.37	0.99	2.22	1.06	135	7	142	7	149	63	2
July 12, 1923	7,180	940	8,120	600	1.79	1.00	1.70	1.23	129	9	138	7	145	50	2
July 30, 1923	8,710	1,000	9,710	620	1.49	.78	1.42	1.13	130	8	138	7	145	34	2
Yellow sweet clover															
April 12, 1923	...	...	120	650	...	...	4.61	3.92	...	...	5	26	31	96	1
May 1, 1923	...	...	680	470	...	...	4.47	2.52	...	...	30	12	42	115	1
May 19, 1923	...	...	1,760	590	...	...	3.23	1.69	...	...	57	10	67	130	1
June 2, 1923	...	...	4,520	710	...	...	2.63	1.45	...	...	119	10	129	142	1
June 23, 1923	4,260	620	4,880	600	2.70	.88	2.48	1.34	115	6	121	8	129	92	1
July 12, 1923	4,340	690	5,030	560	1.94	.83	1.79	1.30*	84	6	90	7	97	97	1

*Estimated.

TABLE 4.—Air-dry Yield, Percentage of Nitrogen and Amount of Nitrogen per Acre in Various Crops, Series 2, 1922-23—Cont'd.

Crop and date	Pounds per acre				Percentage of nitrogen				Pounds of nitrogen per acre					Number plants per sq. yard	Number samples averaged
	Hay	Stubble	Tops	Roots	Hay	Stubble	Tops	Roots	Hay	Stubble	Tops	Roots	Total		
Alfalfa															
October 17, 1922	....	....	930	1,530	....	....	3.48	1.91	....	....	32	29	61	466	2
April 12, 1923	....	....	780	740	....	....	4.33	3.15	....	....	34	23	57	376	2
May 1, 1923	....	....	2,050	720	....	....	3.81	2.19	....	....	78	16	94	270	2
May 19, 1923	....	....	3,470	1,160	....	....	3.33	1.92	....	....	116	22	138	285	2
June 2, 1923	....	....	4,990	1,310	....	....	2.51	1.69	....	....	125	22	147	287	2
July 12, 1923	2,050	630	2,680	1,240	3.27	1.29	2.80	1.61	67	8	75	20	95	313	2
July 30, 1923	2,740	680	3,420	1,330	2.54	1.60	2.35	1.91	70	11	81	25	106	234	2
October 6, 1923	....	....	990	2,030	....	....	2.69	1.81	....	....	27	37	64	228	2
Alsike clover															
April 12, 1923	....	....	450	610	....	....	4.00	3.45	....	....	18	21	39	287	1
May 1, 1923	....	....	1,070	540	....	....	3.54	2.69	....	....	38	15	53	167	1
May 19, 1923	....	....	2,320	1,000	....	....	3.30	2.39	....	....	77	24	101	392	1
June 2, 1923	....	....	4,620	780	....	....	2.41	2.23	....	....	111	17	128	327	1
June 23, 1923	5,650	480	6,130	690	2.06	1.43	2.01	2.00	116	7	123	14	137	229	1
July 12, 1923	4,520	290	4,810	370	2.31	1.71	2.27	2.02	104	5	109	8	117	145	1

TABLE 5.—Air-dry Yield, Percentage of Nitrogen and Amount of Nitrogen per Acre in Various Crops, Series 3, 1923-24

Crop and date	Pounds per acre				Percentage of nitrogen				Pounds nitrogen per acre					No. plants per sq. yd.	No. samples averaged
	Hay	Stubble	Tops	Roots	Hay	Stubble	Tops	Roots	Hay	Stubble	Tops	Roots	Total		
							White sweet clover								
Oct. 13, 1923	3090	270	3360	2400	3.01	1.82	2.91	3.37	93	5	98	81	179	147	1
Apr. 19, 1924	....	....	310	2150	....	....	4.34	4.38	....	....	14	94	108	110	1
Apr. 26, 1924	....	....	1100	1620	....	....	4.91	4.35	....	....	54	71	125	109	1
May 16, 1924	....	....	2690	1520	....	....	3.57	3.22	....	....	96	49	145	70	1
May 31, 1924	3340	920	4260	1270	3.56	2.14	3.25	2.56	119	20	139	33	172	134	1
June 4, 1924	3760	1010	4770	1420	3.19	1.78	2.89	2.49	120	18	138	35	173	93	1
June 18, 1924	4760	690	5450	1060	3.00	1.47	2.81	2.13	143	10	153	23	176	99	1
June 28, 1924	5950	1040	6990	960	2.55	1.04	2.32	2.07	152	11	163	20	182	70	1
July 17, 1924	8580	1240	9820	740	2.24	1.08	2.09	1.82	192	13	205	14	219	35	1
							Yellow sweet clover								
Oct. 13, 1923	2520	300	2820	3110	2.73	1.85	2.64	3.35	69	5	74	104	178	127	1
Apr. 19, 1924	....	....	790	1900	....	....	4.51	4.63	....	....	36	88	124	108	1
May 16, 1924	....	....	2570	1260	....	....	3.72	2.97	....	....	96	37	133	116	1
June 4, 1924	3600	740	4340	1090	3.63	1.90	3.33	2.39	131	14	145	26	171	106	1
June 18, 1924	4700	610	5310	1110	2.93	1.67	2.79	2.42	138	10	148	27	175	113	1
July 17, 1924	5180	720	5900	500	2.38	1.06	2.22	1.89	123	8	131	10	141	41	1
							Alsike clover								
Apr. 19, 1924	....	....	780	440	....	....	3.63	3.61	....	....	28	16	44	49	1
June 18, 1924	4800	280	5080	430	2.77	2.09	2.73	1.97	133	6	139	9	148	89	1

TABLE 6.—Air-dry Yield, Percentage of Nitrogen and Amount of Nitrogen per Acre in Various Crops, Series 5, 1924-25

Crop and date	Pounds per acre				Percentage of nitrogen				Pounds nitrogen per acre					Number plants per sq. yard	Number samples averaged
	Hay	Stubble	Tops	Roots	Hay	Stubble	Tops	Roots	Hay	Stubble	Tops	Roots	Total		
White sweet clover															
November, 1924	....	....	700	2,100	....	....	2.51†	3.50†	....	....	18	73	91	176	4
April 11, 1925	....	....	450	760	....	....	4.11	2.87	....	....	19	22	41	147	1
May 9, 1925	2,440	510	2,950	880	3.51	1.96*	3.24	2.06	86	10	96	18	114	160	1
May 30, 1925	3,670	700	4,370	930	2.82*	1.59*	2.62*	1.82*	104	11	115	17	132	118	1
June 6, 1925	4,690	1,080	5,770	980	2.69	1.47*	2.46	1.95	126	16	142	19	161	121	1
July 6, 1925	5,920	830	6,750	910	2.22	1.03*	2.07	1.72	131	9	140	16	156	85	1
Ordinary yellow sweet clover															
November, 1924	....	....	370	1,460	....	....	2.59	3.08	....	....	10	45	55	287	1
April 11, 1925	....	....	610	790	....	....	3.86	3.08	....	....	24	24	48	212	1
May 9, 1925	1,910	450	2,360	1,070	3.42	2.21	3.19	1.83	65	10	75	20	95	336	1
June 6, 1925	5,180	760	5,940	790	2.62	1.75*	2.51	1.57	136	13	149	12	161	193	1
July 4, 1925	3,950	600	4,550	620	2.36	1.60*	2.26	1.50	93	10	103	9	112	147	1
Albotrea yellow sweet clover															
November, 1924	....	....	500	2,620	....	....	1.94	2.91	....	....	10	76	86	227	1
April 11, 1925	....	....	770	1,300	....	....	3.80	2.86	....	....	29	37	66	247	1
May 9, 1925	2,430	480	2,910	1,130	3.46	2.22*	3.26	2.06	84	11	95	23	118	131	1
June 6, 1925	4,510	900	5,410	970	2.60	1.75*	2.45	1.79	117	16	133	17	150	148	1
July 4, 1925	4,020	820	4,840	680	2.08	1.60*	2.00	1.50	84	13	97	10	107	82	1

TABLE 6.—Air-dry Yield, Percentage of Nitrogen and Amount of Nitrogen per Acre in Various Crops, Series 5, 1924-25—Continued

Crop and date	Pounds per acre				Percentage of nitrogen				Pounds nitrogen per acre					Number plants per sq. yard	Number samples averaged
	Hay	Stubble	Tops	Roots	Hay	Stubble	Tops	Roots	Hay	Stubble	Tops	Roots	Total		
Yellow sweet clover, average both varieties															
November, 1924	....	....	430	2,040	....	....	2.27	3.00	....	....	10	61	71	257	2
April 11, 1925	....	....	690	1,040	....	....	3.83	2.97	....	....	26	31	57	230	2
May 9, 1925	2,170	460	2,630	1,100	3.44	2.22	3.23	1.95	75	10	85	21	106	233	2
June 6, 1925	4,840	830	5,670	880	2.61	1.75*	2.48	1.68	126	15	141	15	156	171	2
July 4, 1925	3,980	710	4,680	650	2.22	1.60*	2.13	1.50	89	11	100	10	110	115	2
															2
Grundy County white sweet clover															
November, 1924	....	....	280	1,120	....	....	2.28	3.70	....	....	7	41	48	165	1
June 6, 1925	3,070	590	3,660	680	2.73	1.47*	2.53	1.91	84	9	93	13	106	100	1
July 3, 1925	4,350	960	5,310	780	2.29	1.03*	2.06	1.52	100	10	110	12	122	78	1
Pearson white sweet clover															
November, 1924	....	....	310	1,310	....	....	2.72	3.47	....	....	8	46	54	185	1
June 6, 1925	3,710	580	4,290	680	2.65*	1.47*	2.48*	1.91*	98	9	107	13	120	115	1
July 3, 1925	3,890	780	4,670	700	2.05*	1.03*	1.88*	1.52*	80	8	88	11	99	122	1
Alfalfa															
November, 1924	....	....	1,060	1,430	....	....	3.24	2.66	....	....	34	38	72	300	2
April 18, 1925	....	....	1,970	1,080	....	....	3.19	2.34	....	....	63	25	88	281	2
May 9, 1925	2,600	860	3,460	1,320	3.13	2.10*	2.87	2.09	81	18	99	28	127	254	2
June 6, 1925	2,860	1,050	3,910	1,310	2.45	2.10*	2.36	2.33	70	22	92	31	123	177	2
July 17, 1925	2,480	850	3,330	1,910	2.48	1.80*	2.31	2.41	62	15	77	46	123	177	2
September 9, 1925	1,660	1,060	2,720	2,300	2.66	1.90*	2.36	2.20	44	20	64	51	115	171	2
November 9, 1925	570	700	1,270	2,210	2.95	2.10*	2.49	2.12	17	15	32	47	79	163	2

TABLE 6.—Air-dry Yield, Percentage of Nitrogen and Amount of Nitrogen per Acre in Various Crops, Series 5, 1924-25—Concluded

Crop and date	Pounds per acre				Percentage of nitrogen				Pounds nitrogen per acre					Number plants per sq. yard	Number samples averaged
	Hay	Stubble	Tops	Roots	Hay	Stubble	Tops	Roots	Hay	Stubble	Tops	Roots	Total		
Red clover															
November, 1924	....	....	1,190	810	....	....	2.84	2.76	....	....	34	22	56	259	1
April 11, 1925	....	....	760	910	....	....	2.65	2.11	....	....	20	19	39	240	1
May 9, 1925	1,540	790	2,330	1,090	3.08	2.20*	2.78	2.19	48	17	65	24	89	220	1
June 6, 1925	2,490	1,300	3,790	1,170	2.36	2.00*	2.24	2 19	59	26	85	26	111	215	1
July 4, 1925	2,910	930	3,840	1,170	1.94	1.80*	1.91	2.20	56	17	73	26	99	137	1
Mammoth clover															
November, 1924	....	....	1,180	700	....	....	2.86	2.30	....	....	34	16	50	273	1
April 11, 1925	....	....	1,190	1,150	....	....	2.78	1.99	....	....	33	23	56	155	1
May 9, 1925	1,380	680	2,060	920	3.38	2.20*	2.89	2.13	45	15	60	20	80	150	1
June 6, 1925	2,440	1,340	3,780	1,220	2.75	2.00*	2.48	2.04	67	27	94	25	119	163	1
July 3, 1925	3,420	1,090	4,510	1,010	2.23	1.80*	2.13	2.30	76	20	96	23	119	99	1
Alsike clover															
November, 1924	....	....	880	800	....	....	3.02	2.94	....	....	27	23	50	316	1
April 11, 1925	....	....	1,070	710	....	....	2.69	2.48	....	....	29	18	47	262	1
May 9, 1925	1,630	810	2,440	1,220	3.39	2.20*	3.00	2.42	55	18	73	30	103	343	1
June 6, 1925	2,920	850	3,770	1,030	2.64	2.00*	2.50	2.15	77	17	94	22	116	236	1
July 3, 1925	1,950	920	2,870	880	2.48	1 80*	2.26	2.25	48	17	65	20	85	201	1

*Estimated.

TABLE 7.—Air-dry Yield, Percentage of Nitrogen and Amount of Nitrogen per Acre in White Sweet Clover, Series 6, 1924-25

Date	Pounds per acre				Percentage of nitrogen				Pounds nitrogen per acre					No. plants per sq. yd.	No. samples averaged
	Hay	Stubble	Tops	Roots	Hay	Stubble	Tops	Roots	Hay	Stubble	Tops	Roots	Total		
July 17, 1924	....	....	540	50	....	....	2.69	2.60	......	......	15	1	16	180	1
Sept. 13, 1924	....	....	880	660	....	....	3.25	3.02	......	......	29	20	49	102	1
Oct. 4, 1924	....	....	1250	1400	....	....	2.66	3.09	......	......	33	43	76	168	4
Oct. 18, 1924	....	....	730	2180	....	....	2.53	3.33	......	......	19	73	92	120	4
Nov. 8, 1924	....	....	740	2600	....	....	2.64	3.55	......	......	20	92	112	162	4
Nov. 25, 1924	....	....	600	2630	....	....	2.36	3.76	......	......	14	99	113	157	4
Mar. 26, 1925	....	....	290	1430	....	....	4.66	3.93	......	......	14	56	70	130	4
Apr. 3, 1925	....	....	470	1240	....	....	4.34	4.15	......	......	20	52	72	124	4
Apr. 10, 1925	....	....	800	1080	....	....	4.05	4.01	......	......	33	43	76	132	4
Apr. 17, 1925	....	....	1300	1030	....	....	3.70	3.39	......	......	48	35	83	148	4
Apr. 24, 1925	....	....	1950	920	....	....	3.60	2.83	......	......	70	26	96	133	4
May 2, 1925	2360	530	2890	970	3.71	*2.10	3.41	2.46	88	11	99	24	123	141	4
May 8, 1925	2910	590	3500	880	3.47	*1.96	3.22	1.99	101	12	113	18	131	128	4
May 16, 1925	3500	670	4170	860	3.58	1.83	3.30	1.95	125	12	137	17	154	95	4
May 22, 1925	3730	1000	4730	1010	3.08	*1.71	2.79	1.93	115	17	132	20	152	95	4
May 30, 1925	4430	1090	5520	940	2.82	*1.59	2.58	1.82	125	17	142	17	159	77	4
June 6, 1925	5330	1010	6340	950	2.46	*1.47	2.30	1.75	131	15	146	17	163	81	4
June 13, 1925	5320	1020	6340	820	2.30	1.34	2.15	1.86	122	14	136	15	151	68	4
June 20, 1925	5490	1060	6550	790	2.07	*1.23	1.93	1.93	114	13	127	15	142	66	4
June 26, 1925	6200	1190	7390	850	1.90	*1.13	1.78	1.46	118	13	131	13	144	54	4
July 3, 1925	6790	1110	7900	790	1.87	*1.03	1.75	1.56	127	11	138	12	150	47	4
July 11, 1925	5950	1120	7070	750	1.80	*1.00	1.67	1.33	107	11	118	10	128	43	4
July 18, 1925	5790	950	6740	620	1.80	*1.00	1.69	1.50	104	10	114	9	123	33	4
July 25, 1925	5260	920	6180	560	1.80	*1.00	1.68	1.46	95	9	104	8	112	33	4

*Estimated.

TABLE 8.—Air-dry Yield, Percentage of Nitrogen and Amount of Nitrogen per Acre in Various Crops Sown Alone, Single Samples, Series 7, 1924-1925

Date and crop	Pounds per acre				Percentage of nitrogen				Pounds nitrogen per acre					No. plants per sq. yd.
	Hay	Stubble	Tops	Roots	Hay	Stubble	Tops	Roots	Hay	Stubble	Tops	Roots	Total	
White sweet clover														
July 23, 1924	4810	380	5190	880	2.81	1.61	2.72	3.36	135	6	141	30	171	332
Sept. 13, 1924	5640	300	5940	2810	2.39	1.76	2.36	2.88	135	5	140	81	221	187
Oct. 23, 1924	3990	630	4620	5360	1.66	†2.46	1.77	3.00	66	16	82	161	243	287
Mar. 26, 1925	......	......	310	2960	......	......	4.14	3.66	......	......	13	108	121	145
Apr. 25, 1925	......	......	2580	2130	......	......	4.04	3.77	......	......	104	80	184	197
May 23, 1925	4450	930	5380	1800	3.17	*1.71	2.92	2.85	141	16	157	51	208	132
June 22, 1925	6360	660	7020	1340	2.02	*1.20	1.94	1.37	128	8	136	19	155	56
Ordinary yellow sweet clover														
Oct. 23, 1924	3340	520	3860	4600	1.95	†2.24	1.99	3.27	65	12	77	150	227	223
Mar. 26, 1925	......	......	590	3500	......	......	4.10	3.47	......	......	24	122	146	241
Apr. 25, 1925	......	......	3480	2230	......	......	3.88	2.39	......	......	135	53	188	296
May 23, 1925	4700	1040	5740	1680	3.12	*1.71	2.86	2.10	147	18	165	35	200	215
Albotrea yellow sweet clover														
Oct. 28, 1924	3710	420	4130	5970	1.50	1.67	1.52	2.97	56	7	63	177	240	287
May 23, 1925	4300	960	5260	1400	3.38	*1.71	3.07	2.31	145	17	162	32	194	108

TABLE 8.—Air-dry Yield, Percentage of Nitrogen and Amount of Nitrogen per Acre in Various Crops Sown Alone, Series 7, Single Samples, 1924-25—Continued

Date and crop	Pounds per acre				Percentage of nitrogen				Pounds nitrogen per acre					No. plants per sq. yd.
	Hay	Stubble	Tops	Roots	Hay	Stubble	Tops	Roots	Hay	Stubble	Tops	Roots	Total	
Grundy Co. white sweet clover														
Oct. 23, 1924	1830	430	2260	3880	2.04	†2.94	2.21	3.30	37	13	50	128	178	170
May 23, 1925	3660	1020	4680	1740	3.19	*1.71	2.87	2.47	117	17	134	43	177	194
Pearson white sweet clover														
Oct. 23, 1924	2450	460	2910	6270	1.96	†2.79	2.09	3.39	48	13	61	213	274	239
May 23, 1925	4190	1120	6310	1610	*3.19	*1.71	*2.42	*2.47	134	19	153	40	193	168
Mammoth clover														
Nov. 8, 1924	....	....	2670	1060	....	....	2.76	2.88	....	....	74	31	104	252
May 16, 1925	3010	1140	4150	1350	3.59	*2.10	3.18	2.12	108	24	132	29	161	218
June 22, 1925	4240	760	5000	820	2.14	*1.90	2.10	2.28	91	14	105	19	124	104
Red clover														
Nov. 8, 1924	....	....	2090	1230	....	....	2.77	2.56	....	....	58	32	90	259
May 16, 1925	2510	1240	3750	1410	3.17	*2.10	2.82	1.96	80	26	106	28	134	126
June 22, 1925	2850	880	3730	1000	2.01	*1.90	1.98	2.21	57	17	74	22	96	97

*Estimated.
†These high percentages in the stubble seem to be due to clipping some root material into the stubble.

TABLE 9.—Percentage and Amount per Acre of Nitrogen, Phosphorus, Potassium, Calcium, and Magnesium in White Sweet Clover, Series 6, 1924-1925

Date	Part of plant	Pounds per acre	Percentage present on air-dry basis						Pounds per acre				
			Total ash	N	P	K	Ca	Mg	N	P	K	Ca	Mg
1924 July 17	Tops	540	9.37	2.69	0.22	3.27	1.02	0.25	14.5	1.2	17.7	5.5	1.4
September 13	Tops	880	10.42	3.23	.24	1.67	1.58	.37	28.4	2.1	14.7	13.9	3.3
	Roots	660	.....	3.02	.28	.97	.20	.03	19.9	1.8	6.4	1.3	.2
	Total	1,540	.....	.....	.....	.....	.....	.....	48.3	3.9	21.1	15.2	3.5
October 4	Tops	1,250	9.62	2.66	.19	1.80	1.46	.30	33.3	2.4	22.5	18.3	3.8
	Roots	1,400	.....	3.16	.25	.80	.23	.09	44.2	3.5	11.2	3.2	1.3
	Total	2,650	.....	.....	.....	.....	.....	.....	77.5	5.9	33.7	21.5	5.1
October 18	Tops	730	11.46	2.53	.16	1.80*	1.96	.37	18.5	1.2	13.1	14.3	2.7
	Roots	2,180	.....	3.43	.27	.85	.21	.08	74.8	5.9	18.5	4.6	1.7
	Total	2,910	.....	.....	.....	.....	.....	.....	93.3	7.1	31.6	18.9	4.4
November 8	Tops	740	9.83	2.64	.15	1.81	1.69	.37	19.5	1.1	13.4	12.5	2.7
	Roots	2,600	.....	3.68	.26	.69	.19	.13	95.7	6.8	17.9	4.9	3.4
	Total	3,340	.....	.....	.....	.....	.....	.....	115.2	7.9	31.3	17.4	6.1
November 25	Tops	600	11.06	2.36	.14	1.80	1.61	.38	14.2	.8	10.8	9.7	2.3
	Roots	2,630	.....	3.81	.32	.69*	.19	.15	100.2	8.4	18.1	5.0	4.2
	Total	3,230	.....	.....	.....	.....	.....	.....	114.4	9.2	28.9	14.7	6.5
1925 March 26	Tops	290	.....	4.68	.48	2.05	.89	.58	13.6	1.4	5.9	2.6	1.7
	Roots	1,430	.....	3.84	.39	1.06	.34	.33	54.9	5.6	15.2	4.9	4 7
	Total	1,720	.....	.....	.....	.....	.....	.....	68.5	7.0	21.1	7.5	6.4

TABLE 9.—Percentage and Amount per Acre of Nitrogen, Phosphorus, Potassium, Calcium, and Magnesium in White Sweet Clover, Series 6, 1924-25—Continued

Date	Part of plant	Pounds per acre	Percentage present on air-dry basis						Pounds per acre				
			Total ash	N	P	K	Ca	Mg	N	P	K	Ca	Mg
1925													
	Tops	470	....	4.39	.50	1.91	1.25	.49	20.6	2.4	9.0	5.9	2.3
	Roots No. 1	1,120	....	4.46	.42	1.22	.32	.28	50.0	4.7	13.7	3.6	3.1
	Roots No. 2	1,010	....	4.35	.40	1.27	.31	.38	43.9	4.0	12.8	3.1	3.8
April 3	Roots No. 3	1,260	....	3.80	.41	1.28	.29	.35	47.9	5.2	16.1	3.7	4.4
	Roots No. 4	1,560	....	4.00	.46	1.30	.34	.36	62.4	7.2	20.3	5.3	5.6
	Roots average	1,240	....	4.15	.42	1.27	.32	.34	51.5	5.2	15.7	4.0	4.2
	Total	1,710	....	....	....	....	....	....	72.1	7.6	24.7	9.9	6.5
	Tops	1,300	....	3.47	.27	2.22	2.42	.72	45.1	3.5	28.9	31.5	9.4
April 17	Roots	1,030	....	3.44	.41	1.76	.41	.45	35.4	4.2	18.1	4.2	4.6
	Total	2,330	....	....	....	....	....	....	80.5	7.7	47.0	35.7	14.0
	Hay	2,360	....	3.60	.29	2.00	1.76	.35	85.0	6.8	47.2	41.5	8.3
	Stubble	530	....	2.10*	.18*	2.30*	1.22*	.35*	11.1	1.0	12.2	6.5	1.8
May 2	Tops	2,890	....	3.33	.25	2 06	1.66	.35	96.1	7.8	59.4	48.0	10.1
	Roots	970	....	2.39	.18	1.92	.49	.71	23.2	1.7	18.6	4.8	6.9
	Total	3,860	....	....	....	....	....	....	119.3	9.5	78.0	52.8	17.0
	Hay	3,500	....	3.41	.28	1.86	1.55	.28	119.4	9.8	65.1	54.3	9.8
	Stubble	670	....	1.83	.18	2.28	.97	.45	12.3	1.2	15.3	6.5	3.0
May 16	Tops	4,170	....	3.16	.26	1.93	1.46	.31	131.7	11.0	80.4	60.8	12.8
	Roots	860	....	2.16	.28	1.86	.49	.49	18.6	2.4	16.0	4.2	4.2
	Total	5,030	....	....	....	....	....	....	150.3	13.4	96.4	65.0	17.0
	Hay	4,430	....	2.79	.28	1.82	1.25	.32	123.6	12.4	80.6	55.4	14.2
	Stubble	1,090	....	1.59*	.20*	2.10*	.82*	.50*	17.3	2.2	22.9	8.9	5.5
May 30	Tops	5,520	....	2.55	.26	1.87	1.16	.36	140.9	14.6	103.5	64.3	19.7
	Roots	940	....	1.81	.33	2.11	.56	.50	17.0	3.1	19.8	5.3	4.7
	Total	6,460	....	....	....	....	....	....	157.9	17.7	123.3	69.6	24.4

TABLE 9.—Percentage and Amount per Acre of Nitrogen, Phosphorus, Potassium, Calcium, and Magnesium in White Sweet Clover, Series 6, 1924-25—Concluded

Date	Part of plant	Pounds per acre	Percentage present on air-dry basis						Pounds per acre				
			Total ash	N	P	K	Ca	Mg	N	P	K	Ca	Mg
1925													
	Hay No. 1	5,380	....	2.33	.17	1.85	1.07	.24	127.7	9.3	101.4	58.6	13.2
	Hay No. 2	5,990	....	2.55	.13	1.95	1.20	.32	152.7	7.8	116.8	71.9	19.2
	Hay No. 3	4,590	....	1.94	.21	2.00	1.01	.20	89.0	9.6	91.8	46.4	9.2
	Hay No. 4	5,220	....	2.27	.23	1.89	.93	.25	118.5	12.0	98.7	48.5	13.1
June 13	Hay average	5,320	....	2.27	.19	1.92	1.05	.25	120.8	10.1	102.1	55.9	13.3
	Stubble	1,020	....	1.34	.22	1.90	.67	.55	13.7	2.2	19.4	6.8	5.6
	Tops	6,340	....	2.12	.19	1.92	.99	.30	134.5	12.3	121.5	62.7	18.9
	Roots	820	....	1.80	.24	1.85	.61	.46	14.8	2.0	15.2	5.0	3.8
	Total	7,160	....	....	....	....	....	....	149.3	14.3	136.7	67.7	22.7
1924													
	Hay	6,200	....	1.77	.20	2.10	.91	.17	100.7	12.4	130.2	56.4	16.5
	Stubble	1,190	....	1.13*	.22*	1.90*	.60*	.25*	13.4	2.6	22.6	7.1	3.0
June 26	Tops	7,390	....	1 67	.20	2.07	.86	.18	123.1	15.0	152.8	63.5	13.5
	Roots	850	....	1.50	.27	1.88	.46	.67	12.8	2.3	16.0	3.9	5.7
	Total	8,240	....	....	....	....	....	....	135.9	17.3	168.8	67.4	19.2
	Hay	5,950	....	1.78	.15	1.94	.80	.15	105.9	8.8	115.4	47.6	8.9
	Stubble	1,120	....	1.00	.22*	1.90*	.50*	.12*	11.2	2.5	21.3	5.6	1.3
July 11	Tops	7,070	....	1.66	.16	1.93	.75	.14	117.1	11.4	136.7	53.2	10.2
	Roots	750	....	1.29	.26	1.87	.65	.65	9.7	2.0	14.0	4.9	4.9
	Total	7,820	....	....	....	....	....	....	126.8	13.4	150.7	58.1	15.1
	Hay	5,260	....	1.81	.25	1.89	.74	.14	95.2	7.9	99.4	38.9	7.4
	Stubble	920	....	1.00*	.22*	1.90*	.44*	.12*	9.2	2.0	17.5	4.0	1.1
July 26	Tops	6,180	....	1.69	.16	1.89	.69	.14	104.4	9.9	116.9	42.9	8.5
	Roots	560	....	1.60	.24	1.85	.60	.46	9.0	1.3	10.4	3.4	2.6
	Total	6,740	....	....	....	....	....	....	113.4	11.2	127.3	46.3	11.1

*Estimated.

TABLE 10.—Percentage and Amount per Acre of Nitrogen, Phosphorus, Potassium, Calcium, and Magnesium in White Sweet Clover

Series and date	Part of plant	Pounds per acre	Percentage present on air-dry basis						Pounds per acre				
			Total ash	N	P	K	Ca	Mg	N	P	K	Ca	Mg
Nurse crop test, 1922 (Aug. 25) and Series 1, (Sept. 6 and 28)													
Aug. 25.........	Tops	2090	9.37	3.04	0.27	....	1.59	0.35	63.5	5.6	....	33.2	7.5
Sept. 6..........	Tops No. 1	1970	16.30	2.98	.30	....	1.44	.40	58.7	5.9	....	28.4	7.9
Sept. 6..........	Tops No. 9	1970	11.09	3.18	.24	....	1.28	.36	62.7	4.7	....	25.2	7.1
Sept. 28..........	Tops	2360	8.15	3.03	.22	....	1.32	.28	71.5	5.2	....	31.2	6.6
Series 7, sown alone in 1924													
	Hay	4810	6.79	2.81	.27	1.45*	.98	.34	135.2	13.0	69.7	47.1	16.4
	Stubble	380	....	1.61	.20*	1.45*	.90*	.34*	6.1	.8	5.5	3.4	1.3
July 23...........	Tops	5190	....	2.72	.27	1.45*	.97	.34	141.3	13.8	75.2	50.5	17.7
	Roots	880	....	3.36	.30	1.02	.21	.11	29.6	2.6	9.0	1.8	1.0
	Total	6070	....	....	....	....	....	....	170.9	16.4	84.2	52.3	18.7
	Hay	5640	6.63	2.39	.21	1.19*	1.00	.26	134.8	11.8	67.1	56.4	14.7
	Stubble	300	....	1.76	.15*	1.19*	.90*	.26*	5.3	.5	3.6	2.7	0.8
Sept. 13....... .	Tops	5940	....	2.36	.21	1.19*	.99	.26	140.1	12.3	70.7	59.1	15.5
	Roots	2810	....	2.88	.28	.74	.19	.12	80.9	7.9	20.8	5.3	3.4
	Total	8750	....	....	....	....	....	....	221.0	20.2	91.5	64.4	18.9
	Hay	3990	6.28	1.66	.15	.90*	1.14	.28	66.2	6.0	35.9	45.5	11.2
	Stubble	630	....	2.46	.10*	.90*	1.00*	.28*	15.5	.6	5.7	6.3	1.8
Oct. 23..........	Tops	4620	....	1.77	.14	.90*	1.12	.28	81.7	6.6	41.6	51.8	13.0
	Roots	5360	....	3.00	.27	.93	.15	.14	160.8	14.5	49.8	8.0	7.5
	Total	9980	....	....	....	....	....	....	242.5	21.1	91.4	59.8	20.5

*Estimated.

TABLE 11.—Percentage and Amount per Acre of Nitrogen, Phosphorus, Potassium, Calcium, and Magnesium in White Sweet Clover, Series 3, 1923-24

Date	Part of plant	Pounds per acre	Percentage present on air-dry basis						Pounds per acre				
			Total ash	N	P	K	Ca	Mg	N	P	K	Ca	Mg
1923													
Oct. 13...........	Hay	3090	9.06	3.01	0.23	1.80*	1.22	0.25	93.0	7.1	55.6	37.7	17.7
	Stubble	270	....	1.82	.20*	1.80*	.76*	.25*	4.9	0.5	4.9	1.9	.7
	Tops	3360	....	2.91	.23	1.80*	1.17	.25	97.9	7.6	60.5	39.6	8.4
	Roots	2400	....	3.37	.28	1.00	.22	.27	80.9	6.7	24.0	5.3	6.5
	Total	5760	....	....	....	....	....	....	178.8	14.3	84.5	44.9	14.9
1924													
Apr. 19...........	Tops	310	17.72	4.34	.48*	2.20*	.97	.38	13.5	1.5	6.8	3.0	1.2
	Roots	2150	....	4.38	.43	.97	.33	.23	94.2	9.2	20.9	7.1	4.9
	Total	2460	....	....	....	....	....	....	107.7	10.7	27.7	10.1	6.1
Apr. 26...........	Tops	1100	11.40	4.91	.39	2.10*	1.35	.44	54.0	4.3	23.1	14.9	4.8
	Roots	1620	....	4.35	.31	.85	.35	.18	70.5	5.0	13.8	5.7	2.9
	Total	2720	....	....	....	....	....	....	124.5	9 3	36.9	20.6	7.7
May 16...........	Tops	2690	15.54	3.57	.34	1.86*	1.50	.39	96.0	9.1	50.0	40.4	10.5
	Roots	1520	....	3.22	.30	1.33	.46	.34	48.9	4.6	20.2	7.0	5.2
	Total	4210	....	....	....	....	....	....	144.9	13.7	70.2	47.4	15.7
May 31...........	Hay	3340	9.43	3.56	.32	1.82*	1.50	.37	118.9	10.7	60.8	50.1	12.4
	Stubble	920	....	2.14	.20*	1.90*	.82*	.45*	19.7	1.8	17.5	7.5	4.1
	Tops	4260	....	3.25	.29	1.84*	1.35	.39	138.6	12.5	78.3	57.6	16.5
	Roots	1270	....	2.56	.29	1.29	.52	.44	32.5	3.7	16.4	6.6	5.6
	Total	5530	....	....	....	....	....	....	171.1	16.2	94.7	64.2	22.1
June 4......	Hay	3760	10.62	3.19	.31	1.86*	1.49	.35	119.9	11.7	69.9	56.0	13.2
	Stubble	1010	....	1.78	.23	1.36	.79	.39	18.0	2.3	13.7	8.0	3.9
	Tops	4770	....	2.89	.29	1.75	1.34	.36	137.9	14.0	83.6	64.0	17.1
	Roots	1420	....	2.49	.26	1.57	.64	.30	35.4	3.7	22.3	9.1	4.3
	Total	6190	....	....	....	....	....	....	173.3	17.7	105.9	73.1	21.4

TABLE 11.—Percentage and Amount per Acre of Nitrogen, Phosphorus, Potassium, Calcium, and Magnesium in White Sweet Clover, Series 3, 1923-24—Continued

Date	Part of plant	Pounds per acre	Percentage present on air-dry basis						Pounds per acre				
			Total ash	N	P	K	Ca	Mg	N	P	K	Ca	Mg
1924													
	Hay	4760	8.93	3.00	.29	2.00*	1.22	.29	142.8	13.8	95.2	58.1	13.8
	Stubble	690	....	1.47	.22*	1.40*	.64*	.24*	10.1	1.5	9.7	4.4	1.7
June 18...........	Tops	5450	....	2.81	.28	1.92*	1.15	.28	152.9	15.3	104.9	62.5	15.5
	Roots	1060	....	2.13	.29	1.41	.63	.30	22.6	3.1	14.9	6.7	3.2
	Total	6510	....	....	....	....	....	....	175.5	18.4	119.8	69.2	18.7
	Hay	5950	7.32	2.55	.28	1.90*	1.15	.27	151.7	16.7	113.1	68.4	16.1
	Stubble	1040	....	1.04	.22*	1.40*	.60*	.12*	10.8	2.3	14.6	6.2	1.2
June 28......	Tops	6990	....	2.32	.27	1.83*	1.07	.25	162.5	19.0	127.7	74.6	17.3
	Roots	960	....	2.07	.25	1 06	.59	.22	19.9	2.4	10.2	5.7	2.1
	Total	7950	....	....	....	....	....	....	182.4	21.4	137.9	80.3	19.4
	Hay	8580	6.37	2.24	.22	1.90*	1.00	.27	192.2	18.9	163.0	85.8	23.2
	Stubble	1240	....	1.08	.22*	1.40*	.45*	.12*	13.4	2.7	17.4	5.6	1.5
	Tops	9820	....	2.09	.22	1.84*	.93	.25	205.6	21.6	180.4	91.4	24.7
July 17.............	Roots	740	....	1.82	.19	1.06	.60	.38	13.5	1.4	7.8	4.4	2.8
	Total	10560	....	....	....	....	....	....	219.1	23.0	188.2	95.8	27.5

TABLE 12.—Percentage and Amount per Acre of Nitrogen, Phosphorus, Potassium, Calcium, and Magnesium in Yellow Sweet Clover

Series and date	Part of plant	Pounds per acre	Percentage present on air-dry basis						Pounds per acre				
			Total ash	N	P	K	Ca	Mg	N	P	K	Ca	Mg
Series 1 1922													
	Tops	1,290	9.42	3.26	.33	1.90	1.62	.47	42.1	4.3	24.5	20.9	6.1
September 28	Roots	3,020	....	2.78	.35	1.00	.29	.34	84.1	10.6	30.2	8.8	10.3
	Total	4,310	....	....	....	....	....	....	126.1	14.9	54.7	29.7	16.4
Series 5 1925													
	Hay	1,910	....	3.42	.30	1.68	1.54	.55	65.3	5.7	32.1	29.4	10.5
	Stubble	450	....	2.21	.18*	2.10*	1.00*	.45*	9.9	0.8	9.5	4.5	2.0
May 9	Tops	2,360	....	3.19	.28	1.76	1.44	.53	75.2	6.5	41.6	33.9	12.5
	Roots	1,070	....	1.83	.12	1.55	1.66	1.05	19.6	1.3	16.6	7.1	11.2
	Total	3,430	....	....	....	....	....	....	94.8	7.8	58.2	41.0	23.7
	Hay	5,180	12.19	2.62	.24	1.82	1.69	.31	135.7	12.4	94.3	87.5	18.1
	Stubble	760	....	1.75*	.20*	2.00*	.90*	.50	13.3	1.5	15.2	6.8	3.8
June 6	Tops	5,940	....	2.51	.23	1.84	1.59	.37	149.0	13.9	109.5	94.3	21.9
	Roots	790	....	1.57	.11	1.85	.58	.85	12.4	.9	14.6	4.6	6.7
	Total	6,630	....	....	....	....	....	....	161.4	14.8	124.1	98.9	28.6

LIFE HISTORY OF SWEET CLOVER AS SHOWN BY THE DATA

GENERAL OBSERVATIONS ON THE DEVELOPMENT OF SWEET CLOVER

Sweet clover is strictly a biennial. In the first season it makes a moderate to very large top growth, and a root growth exceeding the tops before winter in all but unusual circumstances. No bloom has ever been observed at Columbus on biennial sweet clover the first year, altho Pieters and Kephart (21) report bloom in the latitude of Washington, D. C. Large crown buds (Fig. 18) are developed at the base of the plant. They always appear in August, and doubtless could be found somewhat earlier by careful observation. They become larger and more numerous until November. These buds start the next spring, and are the only shoots that sweet clover ever produces from the crown. If cut at any time during either the first or second year's growth, recovery is dependent on branches from the stem.

These crown buds are of the utmost practical importance in handling sweet clover. It is nearly impossible in our climate to kill sweet clover by plowing it in the fall after the crown buds are well formed and considerable reserve material is stored in the roots. In these experiments it was once a serious weed when plowed as early as August 28. Enough plants lived and came up the next spring to seriously affect the yield of wheat. No satisfactory way of fall plowing first-year sweet clover in this climate has yet been worked out.

These crown buds do not usually start at all in the fall. Even if the plant is cut October 1 or earlier they remain dormant until spring. But in the very dry fall of 1924 a considerable percentage of these buds started into growth even where the tops were not clipped, and many where the tops were clipped. This starting in the fall had no apparent effect on winter hardiness. What factor was responsible for this abnormal growth is not clear. It was almost as dry in 1925, but no buds started.

The common strain of white sweet clover usually comes into bloom at Columbus about June 10 to 15, the actual dates in these experiments being in June 12, 1922; June 15, 1923; June 23, 1924, and June 9, 1925. It then continues in bloom for four to six weeks, and expressions like "full bloom" have an indefinite meaning. Yellow sweet clover blooms about a week earlier and more uniformly than white sweet clover, as do the early strains of white sweet clover.

In 1925 the spring, June especially, was very dry, followed by several moderate rains in July. As a result of these rains there was a considerable second crop of bloom. This was especially noticeable in the Pearson strain, but could be noticed in all the sweet clover plots from July 19 to 28.

CHANGES IN STAND DURING THE LIFE HISTORY

In order to understand the other changes which take place in a sweet clover field, it is necessary to understand the changes in number of plants per unit area, or stand. There is normally little loss in stand from the time the oats are cut until the following May. However, as soon as rapid growth in height starts in the second season the plants die very rapidly. This is shown graphically for three years in Figure 1. The mortality appears to be due mainly to shading, but partly to moisture conditions. This is suggested by the fact that in the wet year, 1924, the sudden drop in stand came somewhat later in the season than in other years. Shading seemed to be the dominant factor, however. Not only whole plants died, but leaves and weak stems of the dominant plants died and dropped to the ground in considerable quantity (Fig. 19).

These dead plants, especially the roots, decayed very rapidly, hence there was a constant and unmeasurable loss of dry matter from the stand. No attempt was made in these experiments to separate dead from living tops, but no material was picked off the ground. The plan was to harvest whatever the mowing machine would take. The dead roots, however, were practically rotted out by the time the tops were dead, and were not harvested.

It was noticeable that large sections of the root system died and rotted off before the tops were entirely dead. Practically all harvests in late May or early June showed many plants with large side roots rotted off.

Regardless of the initial stand, the final stand in mature sweet clover was about thirty plants per square yard. All the yields reported were therefore resultants of two opposing conditions—the growth of the plants and the death and decay of many plants and plant parts. However, the dry matter lost in the death of plants was by no means proportional to the decrease in stand. As a concrete example of the variation in the size of roots early in the season, fifty-nine roots in one square yard from Series 1, April 7, 1922, weighed air-dry 332 grams. Sixteen of these roots weighed 188 grams, and the other forty-three weighed only 144 grams. This was an unusually thin stand for the time of year. If a thicker stand had been chosen the contrast might have been even greater.

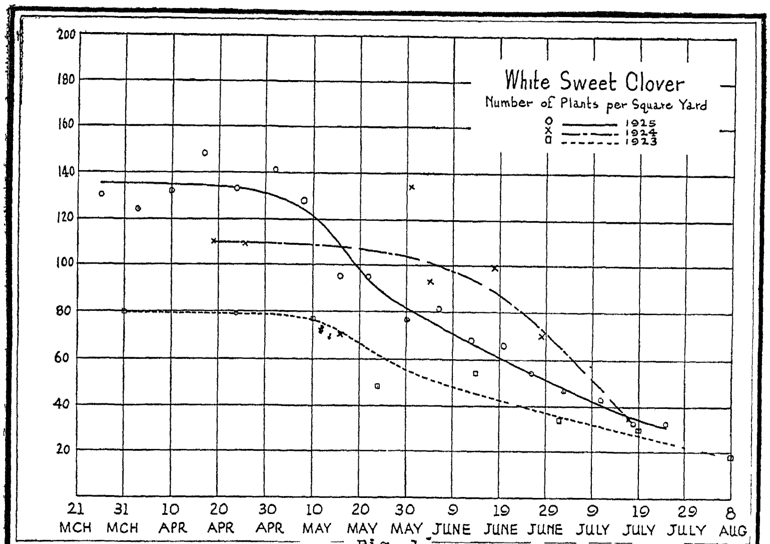

Fig. 1

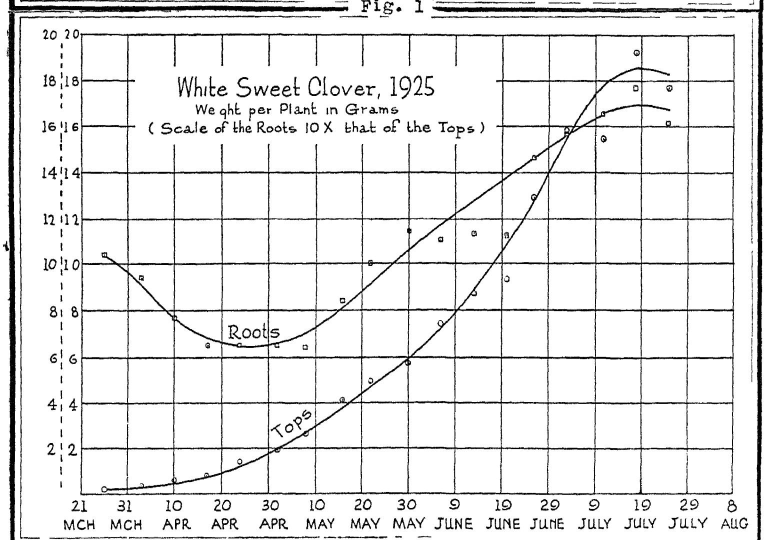

Fig. 2

Fig. 1.—Number of plants per square yard of white sweet clover in 1923, 1924, and 1925. The data are given in Tables 3, 5, and 7.

Fig. 2.—Weight per plant in grams, second-year white sweet clover in Series 6, 1925, The scale for the roots is 10 x that of the tops.

These weaker plants died first, and their death had but little effect on the yield. It is the writer's belief that as much dry weight is lost in leaves and side branches from the dominant plants as by the death of suppressed plants.

DRY MATTER YIELDS OF SWEET CLOVER AT SUCCESSIVE PERIODS

These are shown graphically in Figures 3 and 4. In the first year after the nurse crop was cut there was a slow increase in the tops until about September 30. Their weight then remained fairly constant until freezing killed them. The roots increased in weight rather slowly until the last of September. Then there was a very rapid increase, the weight usually doubling between October 1 and winter. The sweet clover sown alone showed a somewhat similar history, but the maximum of the tops and the rapid storage in the roots came about a month earlier than with that sown in a nurse crop.

In the second year the roots were at first very rapidly depleted to build up the tops. Even the sweet clover sown in July (Series 2, Fig. 9) showed this initial loss of weight from the roots. Regardless of the amount of stored material present in the roots in March, this depletion continued until the total weight of roots reached 1000 to 800 pounds per acre, when it remained nearly constant for the rest of the season. Where there were not 800 pounds of roots per acre present in the spring, they increased in amount after the initial depletion, so that the weight of roots in July was nearly uniform, regardless of the method of planting and amount of growth the preceding year.

The tops grew very rapidly thru the spring and summer and reached a maximum early in July. Then the loss of leaves and small stems overbalanced the growth of seed, and the total weight of tops per acre decreased for the last three or four weeks before the death of the plants, which occurred during August in the ordinary strain of white sweet clover. This decrease at the end of the season is shown in only one of the graphs in Figure 4, but this was in 1925 when the samples were most accurately selected, and the writer strongly believes that it represents the normal course of development.

The probable reason that it did not appear in the other series is that as sweet clover gets older and many plants die, it becomes increasingly difficult to secure accurate samples. Areas of two and three square feet of soil had no living plants on them, and in the six-foot tangle it was very difficult to estimate how much of this

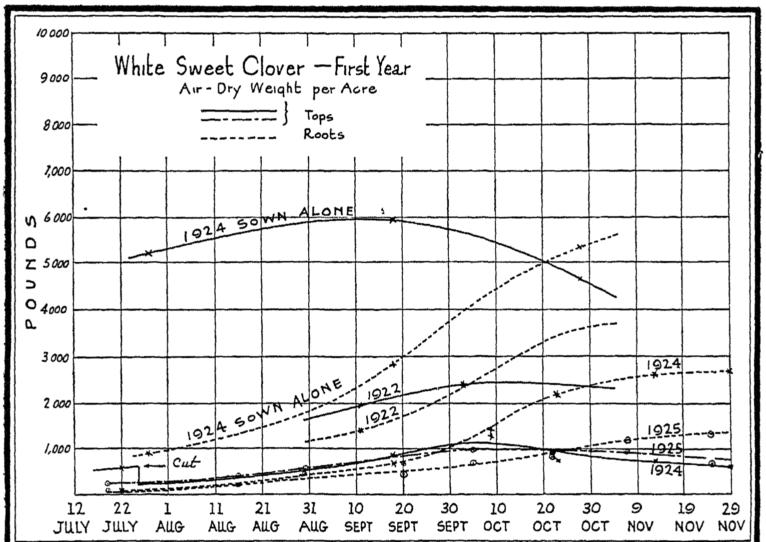

Fig. 3

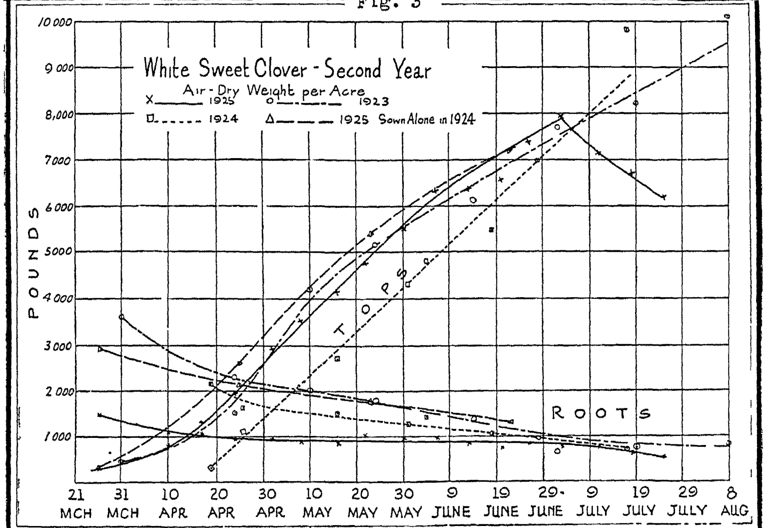

Fig. 4

Fig. 3.—Yields of white sweet clover in the fall of the year it was sown. Data in Tables 3, 7, and 8. The graphs for 1922 are plotted from plots not cut for hay.

Fig. 4.—Yields of white sweet clover in its second year's growth. Data in Tables 3, 5, 7, and 8. The graphs for 1923 are plotted from the average of plots not cut for hay in the fall of 1922.

bare area should be included in the sample. Under these conditions it was easy to select a square-yard sample containing too many of the dominant plants. For this reason the writer feels that these indicated high yields at the end of the season do not represent the facts.

The season in 1924 was very late. By any phenological criterion it was at least two weeks later than 1923 or 1925, and if the 1924 graph were moved over 16 days, it would nearly coincide with the others. This is apparent in most of the data for the year 1924.

Weight of single plants.—The preceding discussion indicates what happens to the stand as a whole during the second year. It is also suggestive to follow the variations in the average weight of single plants. The data from Series 6 only are sufficiently extensive and consistent to be of value for this calculation and these are given graphically in Figure 2. These results seem to indicate that the individual roots increase in weight, even tho the total weight of roots per acre decreases, but this is probably not true, because the plants that die weigh much less than those that remain alive, and the latter would therefore apparently increase in weight whether they actually grew or not.

The steady decrease in the weight of individual roots at the beginning of the season is a feature of this graph.

THE NITROGEN CONTENT OF SWEET CLOVER

The nitrogen content of sweet clover tops in the fall of the first year does not vary greatly from 3 percent. This is also about the average nitrogen content of the first-year roots, tho in July, before storage starts, the roots contain only 2 to 2½ percent. In 1924 the roots increased steadily in percentage of nitrogen during October and early November. In 1925 this did not occur. However, since the roots in the early spring contain 4 to 4½ percent of nitrogen, it is evident that there is a considerable change in composition sometime between fall and spring. This may be connected with the loss in dry matter discussed later, if it exist. The data of Snider and Hein (25) agree with those of 1924 in showing a rather consistent increase in the percentage of nitrogen in the roots during the late fall and early winter. It is probable that this is the normal development, but more data are needed.

The nitrogen content of sweet clover roots and tops in the second year is shown in Figure 5. The depletion of the roots in dry matter in the early spring of the second year is matched by an even more rapid decrease in the percentage of nitrogen in the roots. This emptying into the tops of the nitrogen stored in the roots was the more rapid and complete the less material was stored in the roots the preceding year. This is shown by comparing the 1925 graph for roots with either 1923 or 1924. Figure 10 also emphasizes this point. In 1923, following the very great storage in the roots in the fall of 1922, the roots had a higher percentage of nitrogen than the tops thruout the season. This did not occur in the other years.

After the nitrogen content of the roots is reduced to about 2 percent, further decrease is slow, but the final nitrogen content of the roots in July is about 1.5 percent.

In two of the three years there appeared to be a slight initial increase in the nitrogen content of the tops. However, the 1925 results, which are the most reliable, do not show it. The apparent rise in 1923 was certainly due to an abnormal sample (see Table 2), as some of these samples contained dead tops from the preceding year. In 1924, however, all dead material was carefully removed and yet a rise in nitrogen content was indicated. It was decided therefore to plot the results actually obtained and let future observations decide the question, but the 1925 graph is most likely to be the normal one.

A steady decrease in the nitrogen content of the tops as they approach maturity is shown by Figure 5. It is remarkably uniform for the different years and conditions, except that in 1924 the season was later than in 1923 and 1925. Here again if the graph for 1924 were moved over 16 days earlier it would almost coincide with the others.

Nitrogen per acre in roots and tops.—The nitrogen per acre in the second-year tops and roots is plotted in Figure 6. The difference in nitrogen reserves in the roots at the beginning of the season, due to previous conditions of growth, is brought out by these graphs, as is the fact that the total nitrogen content of the roots in July was nearly constant for all seasons. Figure 8, which compares spring- and summer-sown sweet clover, Series 1 and 2, also illustrates these points.

It is also evident that the final amount of nitrogen in the tops does not depend upon the preceding year's accumulation in the roots. It seems that the second-year tops secure nitrogen from root reserves, if these are available; if not, from the soil and the tubercles on the roots.

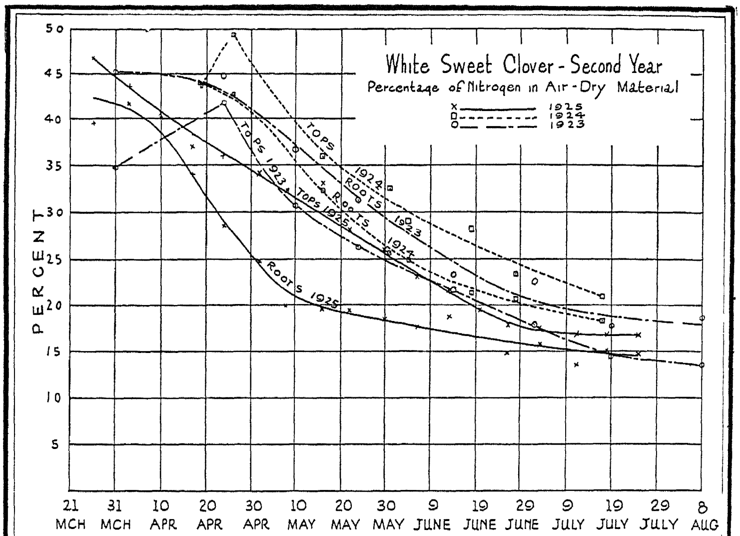

Fig. 5

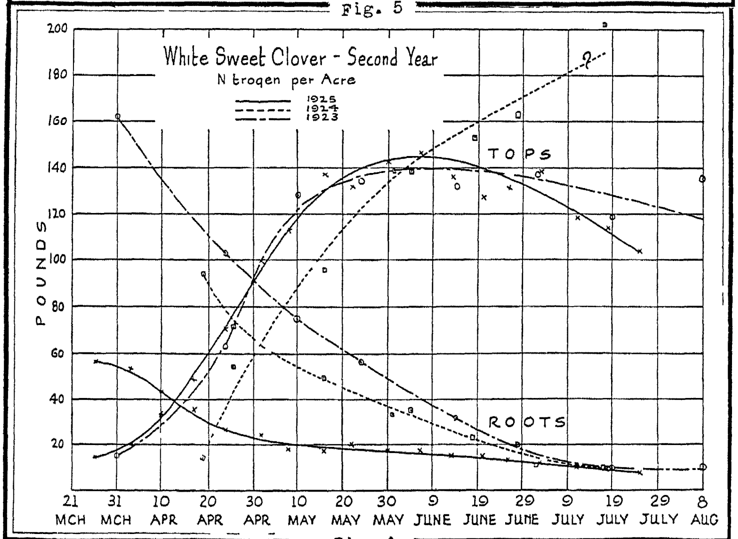

Fig. 6

Fig. 5.—Percentage of nitrogen in air-dry tops and roots of white sweet clover. Data in Tables 3, 5, and 7. The graphs for 1923 are from plots not cut for hay in 1922.

Fig. 6.—Nitrogen per acre in tops and roots of second year white sweet clover. Data in Tables 3, 5, and 7. The graphs for 1923 are from plots not cut for hay in 1922.

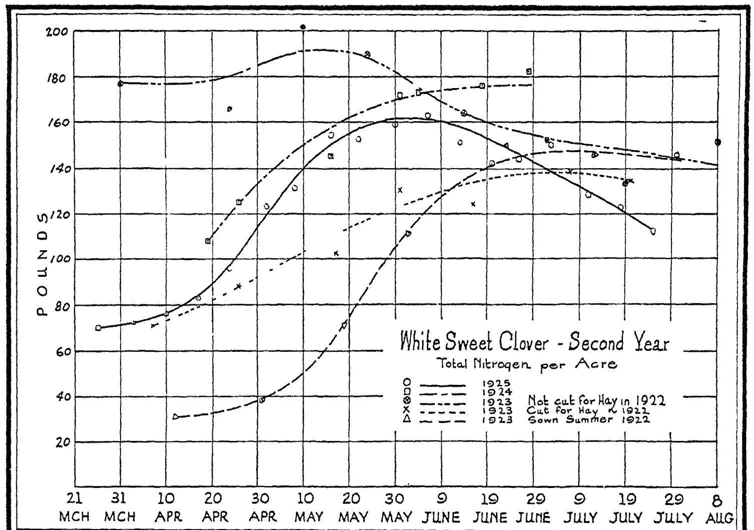

Fig. 7

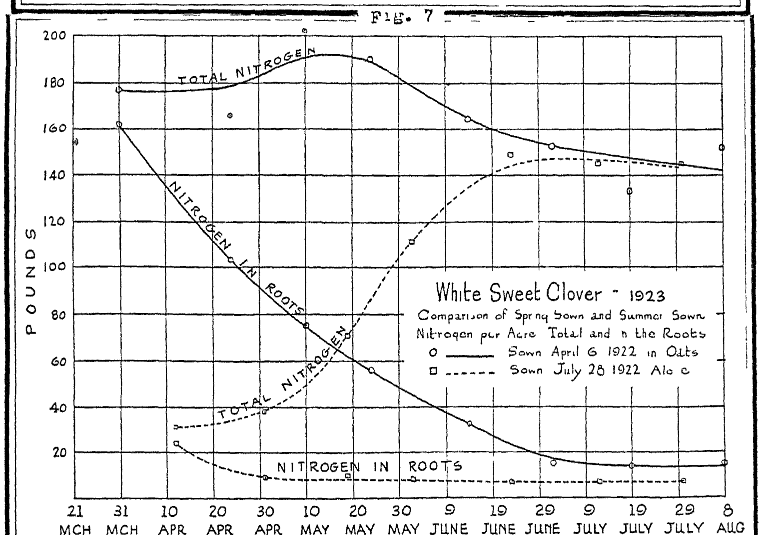

Fig. 8

Fig. 7.—Total nitrogen per acre in second year white sweet clover in 1925, 1924, and in 1923, following three different treatments in 1922. Data in Tables 3, 4, 5, and 7.

Fig. 8.—Nitrogen per acre in sweet clover sown in the spring and in the summer of the preceding year. Data in Tables 3 and 4. Graphs for the spring-sown sweet clover are from the average of plots not cut for hay.

The total nitrogen in the tops usually reaches its maximum by June 15. After this, growth slows up and fails to keep pace with the loss of leaves, stems, and plants from the stand, resulting in an actual loss of nitrogen. The year 1924 is an apparent exception to this but the year was exceptionally favorable for vegetative growth and the season was about two weeks late. Also the 1924 graph is based on single square-yard samples, and so is not as reliable as those of the other years. The sample for July 17, 1924, seems entirely unreliable, for reasons already given.

WHEN SHOULD SWEET CLOVER BE PLOWED DOWN?

The net effect of the various seasons and treatments on the total nitrogen per acre is shown in Figure 7. These data are important in their bearing on the proper time to plow down sweet clover for soil improvement. The time that the maximum nitrogen per acre was reached varied from May 10 in the 1923 series not cut for hay in 1922 to late June in the series cut for hay and that sown in the summer. The data for July 17, 1924 were discarded in making this graph. It is evident that the better the growth in the preceding year, the earlier the maximum amount of nitrogen is accumulated. This is entirely in accord with the investigations of Penny on crimson clover (20).

If sweet clover is not plowed under until June, it is too late to make much use of it that season. The important use of sweet clover in corn-belt rotations is as a catch crop between small grain and corn, shortening the three-year corn-oats-clover or corn-wheat-clover rotations to the two-year rotations corn-oats or corn-wheat. Corn should be planted at Columbus and in the important corn regions of Ohio May 10 to 15 or earlier. To do this the land must be plowed from one to three weeks earlier than this, depending on the size of the farm and the power available for plowing.

What percentage of the total possible nitrogen can be secured when sweet clover is plowed under early enough to permit the planting of corn at the proper time? Taking May 1 as a convenient average date, and calculating the amount of nitrogen per acre in 1922 from the analyses of 1923, we find that as an average of the four years, sweet clover not cut for hay the fall before contained on May 1 about 80 percent of the maximum amount of nitrogen accumulated during the season. The least nitrogen present on May 1 was in 1925 when the crop contained about 120 pounds, or as much as is contained in the grain and stover of 80 bushels of corn.

When so large an amount of nitrogen actually and relatively is present in sweet clover early enough to give the corn the benefit of the full growing season, it seems unwise to delay plowing in order to secure just a little more.*

Two other considerations enter into the question and, in the writer's judgment, clinch the recommendation to plow under sweet clover just as soon as there is sufficient growth to insure that it will be kllled by the plowing.

The first factor is the moisture content of the soil. A dense stand of sweet clover dries the soil rapidly, making it possible in a wet spring to plow sweet clover sod earlier than bare land. But if sweet clover is left until late in May and the spring is dry, the corn crop following will suffer a serious lack of water. Practically total failures of corn have been known to result from leaving sweet clover until late in May in a dry season.

The second factor is perhaps equally as important. Waksman (27) has shown that the percentage of nitrogen in organic matter plowed under vitally affects its value as a source of nitrates for the crop following. This is because the bacteria of decomposition use a considerable amount of nitrogen in building up their own bodies, hence, if the organic matter decomposed is low in nitrogen, all of the nitrogen present may be locked up in bacterial protoplasm so that the higher plants cannot get it; while, if the organic matter is high in nitrogen, there will be an immediate surplus available for the higher plants.

Nothing is more characteristic of sweet clover than the high percentage of nitrogen present in its dry matter during the early stages of growth. This, therefore, should make the early sweet clover especially valuable as a source of nitrates, and practical experience bears this out.

Whiting and Richmond (30) demonstrated that sweet clover plowed under on a variety of soil types actually does furnish large quantities of nitrates to the succeeding crop. However, Figure 5 shows that the percentage of nitrogen in sweet clover decreases so rapidly that an important part of this advantage is lost if it is plowed under after May 10-15. The Illinois Station (11) found that late spring plowing does not yield more nitrates to the succeeding crop than early spring plowing, and their recommendations are in accord with those just made.

Since it is desirable to plow under sweet clover early, perhaps the value of securing a vigorous growth the first year is worth

*This recommendation with data to support it was published earlier (34).

emphasizing. The more growth secured the first season, the more nitrogen will be available for soil improvement at this desirable early date. If a poor growth is secured the first year, either because of summer seeding, poor soil, a very unfavorable season, or too heavy pasturing, it may perhaps be better to let the sweet clover stand for part or all of the second season. The serious effects of cutting sweet clover in the fall, as shown in Table 3, have an especial significance to the man who is trying to build up a depleted soil rapidly.

MINERAL ELEMENTS IN SWEET CLOVER

Considering the degree to which plants vary in mineral composition, the data in Tables 9 to 12 are consistent and satisfactory. The most remarkably feature of the results is the high calcium content of the tops, and especially the rapid intake of calcium in April. The only other extensive mineral analyses of sweet clover known to the writer are unpublished data of Whiting and Richmond.* The material which they used differed from that used by the writer in that it was secured from sweet clover planted in a cultivated row instead of from broadcast stands sown in a nurse crop. In general, however, their figures agree with those given here. They did not begin making analyses of the tops until May 10, too late to show the abrupt rise in percentage of calcium shown by these data, but the rapid drop is very clearly shown. The four analyses by Fulmer (7) are generally consistent with these analyses.

The percentage of total ash in some of these samples seems remarkably high. Some of the higher ones were analyzed twice to be sure of the accuracy of the analysis. The possibility of contamination by soil was considered as an explanation of these high figures, but it does not seem tenable.

SUMMER SEEDING OF SWEET CLOVER

Out of the summer seedings of sweet clover made in this investigation, only one was successful, Series 2 in 1922-23. How white sweet clover in this series compares with that sown in the spring is shown graphically in Figures 8, 9, and 10.

These graphs show that there is little difference between the two times of seeding in the final weight of tops the second year. However, there is a great difference in the amount of nitrogen available for plowing under early in the season, which emphasizes the point that the greater the growth the first year, the earlier the maximum amount of nitrogen is reached and the more material is present to be plowed under in April or early May.

*Since published in Soil Science, 22:83-95. 1926.

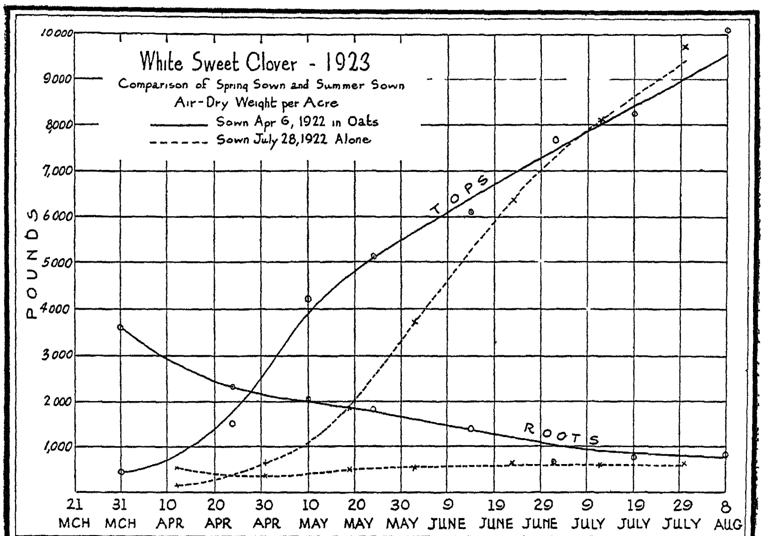

Fig. 9

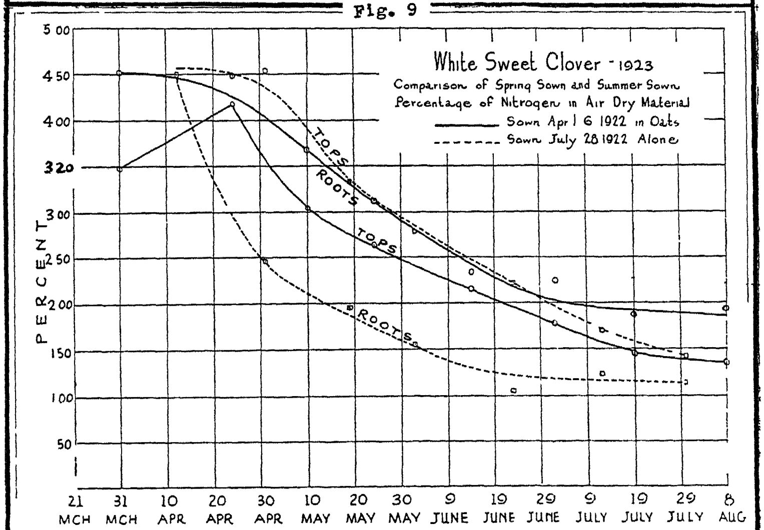

Fig. 10

Fig. 9.—Yield per acre of white sweet clover sown in spring and in summer. Data in Tables 3 and 4. The graphs of spring-sown sweet clover are from plots not cut for hay.

Fig. 10.—Percentage of nitrogen in the roots and tops of white sweet clover sown in the spring and summer of the preceding year. Data in Tables 3 and 4.

An active growth of nodules was present on the roots in both series shown in Figure 8. Series 2 gained nearly 100 pounds of nitrogen from May 10 to June 20; the spring-sown series lost nitrogen in the same period. What was the difference in the activity of the bacterial nodules in the two conditions? It seems that the composition of the plant had some influence on the activities of the nodules, or at least in the amount of nitrogen assimilated from them by the plants.

The graph of dry weight (Fig. 9) shows that the development of the summer-sown series lagged behind the spring-sown series. This was not true of blooming, which was simultaneous on the two series, but the percentage of nitrogen (Fig. 10) bears out the idea that the summer-sown series was less mature, since the tops of that series were always higher in nitrogen than those of Series 1. Figures 20 and 21 illustrate the difference in development of the two series on May 19.

TOP-ROOT RATIO OF SWEET CLOVER AND OTHER CROPS

Some interesting relations are brought out by comparing the percentage of tops in the total dry weight per acre of sweet clover and other crops, (Figs. 11-14). The percentage of tops in the total dry weight rather than the direct top-root ratio was calculated because the former can be more clearly plotted. Values for top-root ratio in this investigation would range from over 10 to under 0.2, and showing this by plotting would not give a clear idea of what was taking place, as does this other form.

The outstanding feature of these graphs is that, regardless of the stage of growth, whether seedling or second year, some physiological factor or factors caused a large proportion of the dry matter to be built into the tops during the months of April to July, inclusive, and into the roots from August to November, inclusive, especially after September 1.

Compare, for example, Figures 22 and 23. The plants in Figure 22 from Series 6, sown in the spring, had 91.5 percent of their total weight in the tops; the plants like Figure 23, sown in August, had only 50 to 60 percent of their weight in the tops. It might be argued that the shading of the nurse crop produced the large percentage of tops in the plants of Figure 22, but Figure 24 shows a plant from Series 7 harvested the same day and sown nearly the same day, only without a nurse crop. The dry weight produced by this seeding of sweet clover was more than ten times that produced in the nurse crop, yet the percentage of total weight in the tops was nearly the same, 85.5 percent.

In the late fall the spring-sown plants appeared like Figure 25, and only 20 to 60 percent of the total weight was tops. Very little of this change was from the dying and dropping of leaves from the tops. Most of it came from increased weight of roots.

The statement has been made (5) that sweet clover develops an extensive root system before making much top growth. This is not true of spring-sown sweet clover under Ohio conditions, and Coe's illustration is of typical summer-sown plants.

In the early spring of the next year all the roots were depleted to form the first top growth, as is brought out in Figures 4 and 9. After this, while some growth took place in the roots, stored materials in the roots were used up and none redeposited there. Nearly all the dry matter produced went into the tops, as it did the first year during the same months, and the percentage of tops in the total rose rapidly to over 90 percent.

The factors which modify root-top ratios in sweet clover are not entirely known. That they are partly hereditary is almost proved by the fact that yellow sweet clover has a decidedly lower percentage of tops in the total weight in the fall of the first year than ordinary white sweet clover, regardless of the time or method of sowing. The early maturing strains of white sweet clover act like yellow sweet clover in this.

That the factors are influenced by climatic conditions is strongly suggested by the fact that in the dry fall of 1924 the percentage of tops in all the plants worked with was much lower than in the favorable moist fall of 1922 (Figs. 13 and 14). This is a well-known phenomenon in root-top ratio studies.

That soil conditions are among these factors or can at least modify them is suggested by a number of observations, of which one on Plot 9 of Series 1 is most significant. About 30 feet of the north end of this plot made the most vigorous top growth secured in the four years' experiments from biennial sweet clover in the fall. This tall growth came to a sudden end, making an almost sharp line in the interior. That it was due to a soil condition is indicated by the fact that the same line and type of growth extended into the adjacent plots of Hubam and alfalfa. The September-28 sample on Plot 9, harvested from the middle of this largest top growth, had 68 percent tops in the total weight. A sample was not harvested in the opposite end, but Plots 1 and 4 were similar in appearance and the samples from these had only 48 percent of tops in the total.

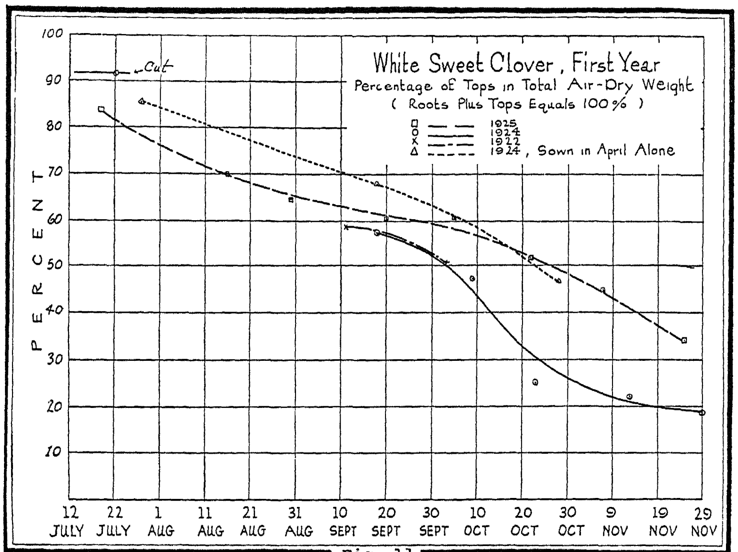

Fig. 11

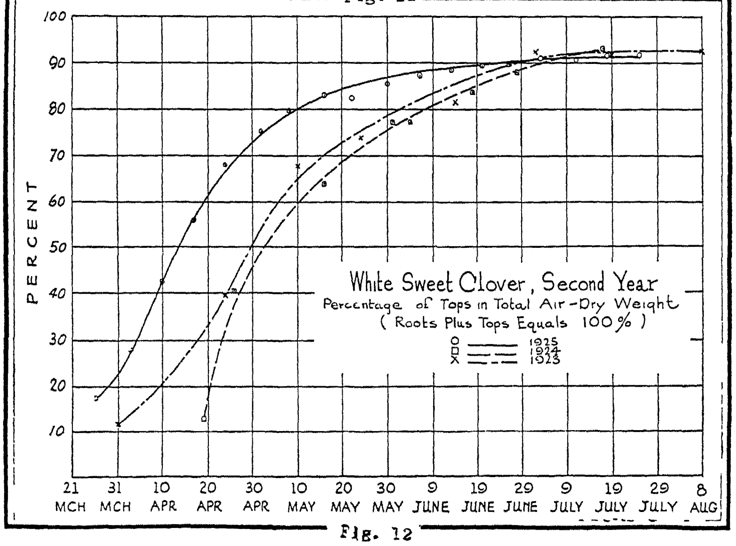

Fig. 12

Fig. 11.—Percentage of tops in total air-dry weight of first-year white sweet clover.

Fig. 12.—Percentage of tops in total air-dry weight of second-year sweet clover. The graph for 1923 is from plots not cut for hay in 1922.

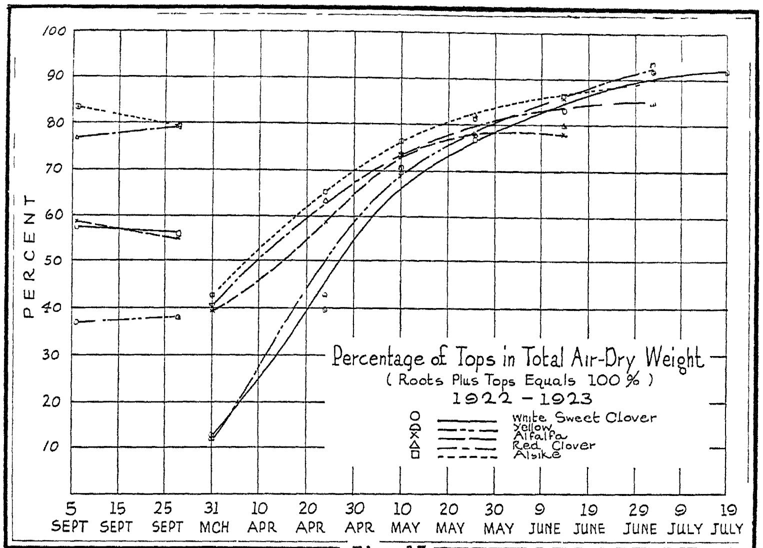

Fig. 13

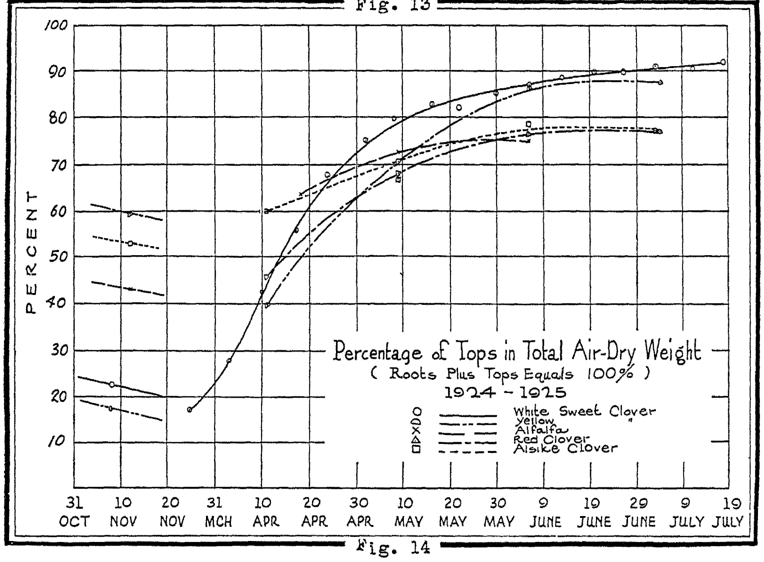

Fig. 14

Fig. 13.—Percentage of tops in total air-dry weight of white sweet clover, yellow sweet clover, alfalfa, red clover, and alsike clover, 1922-23.

Fig. 14.—Percentage of tops in total air-dry weight of white sweet clover, yellow sweet clover, alfalfa, red clover, and alsike clover, 1924-25.

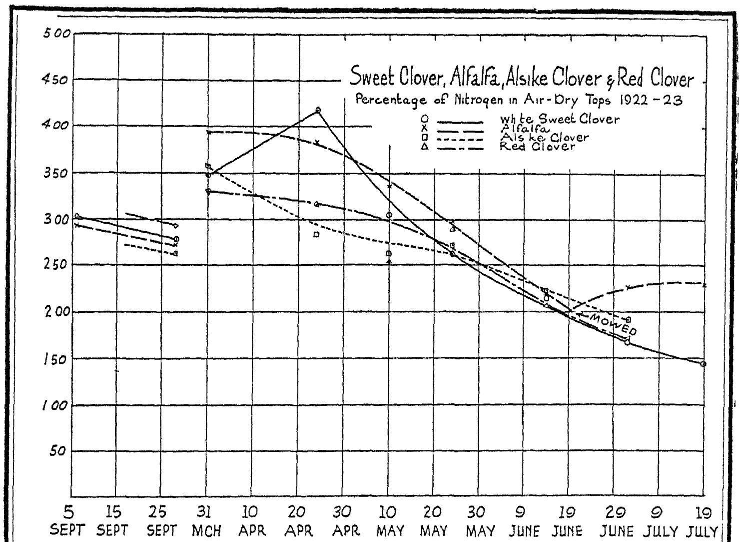

Fig. 15

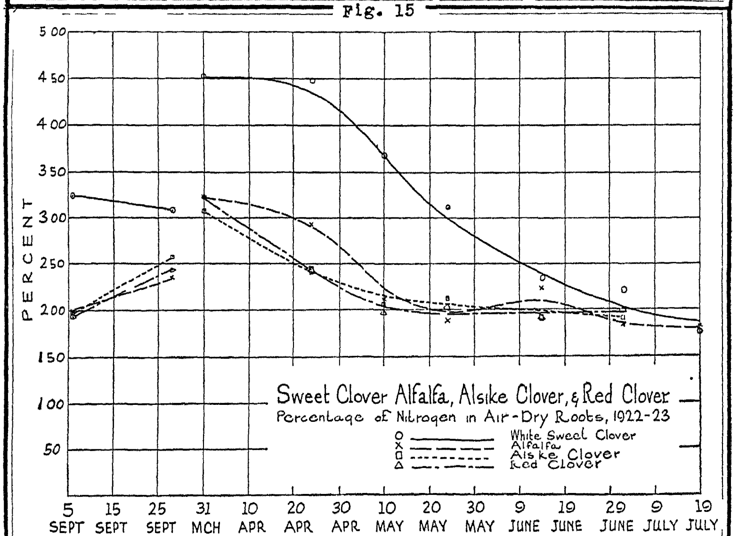

Fig. 16

Fig. 15.—Percentage of nitrogen in the tops of white sweet clover, alfalfa, alsike clover, and red clover, 1922-23. Data in Table 3.

Fig. 16.—Percentage of nitrogen in the roots of white sweet clover, alfalfa, alsike clover, and red clover, 1922-23. Data in Table 3.

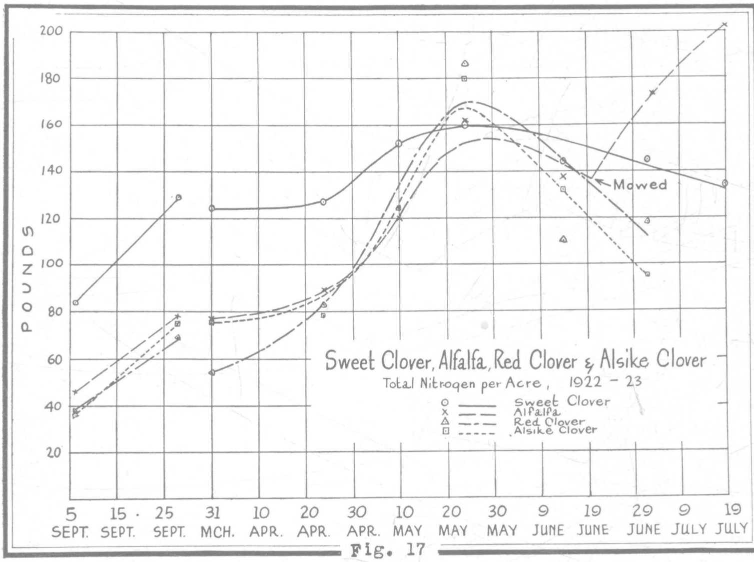

Fig. 17.—Total nitrogen per acre in white sweet clover, alfalfa, red clover, and alsike clover, 1922-23. Data in Table 3.

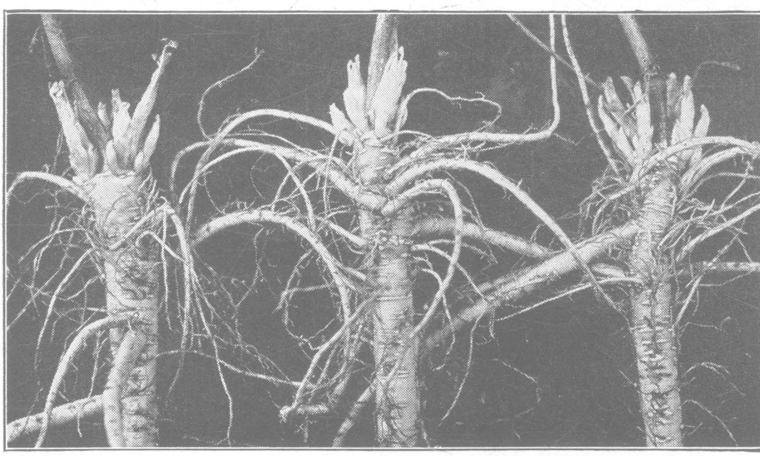

Fig. 18.—Crown buds of white sweet clover, early in November. Plants were taken from Series 3, sown April 12 in oats. Note the nodules on the roots and the abundant surface branching.

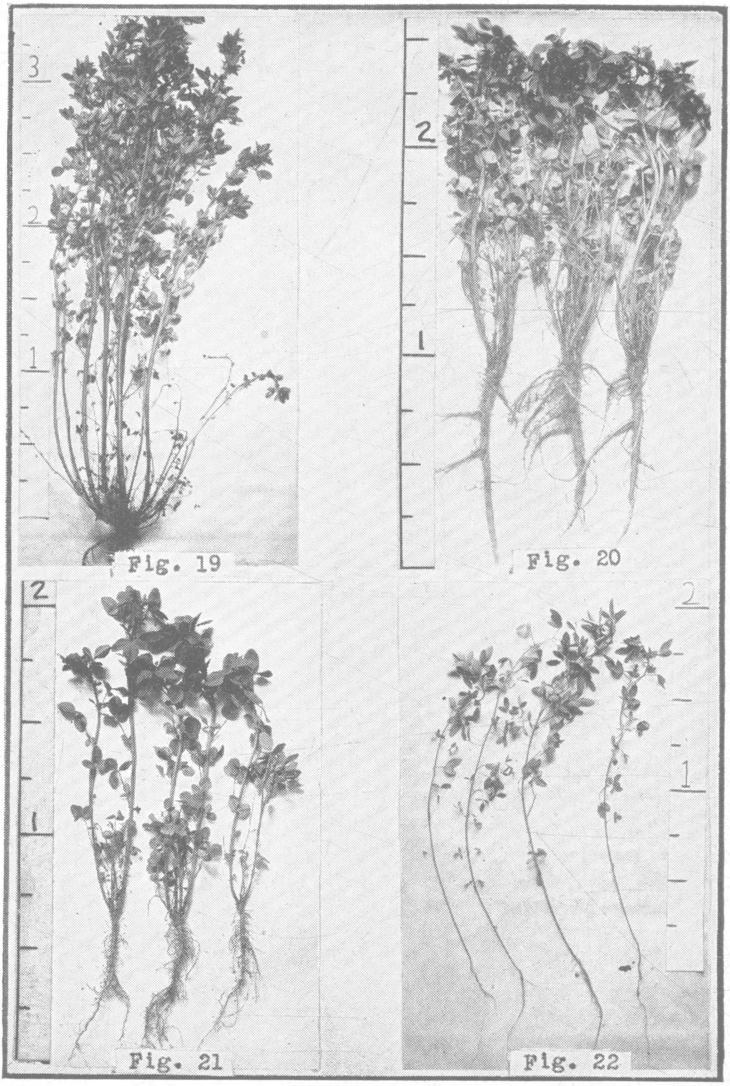

Fig. 19.—A single large plant from Series 6, June 2, 1925, showing the death of numerous shoots, the main stems bare for one foot and the leaves on the next nine inches yellowed and unhealthy.

Fig. 20.—White sweet clover, May 13, 1923, sown April 6, 1922 in oats.

Fig. 21.—White sweet clover, May 19, 1923, sown July 28, 1922 alone.

Fig. 22.—Plants of white sweet clover, July 17, 1924, from Series 6, sown in oats April 12, 1924. Note the very small root system.

The growth made by the biennial sweet clover on Plot 9 resembled that ordinarily made by the annual mutation, Hubam. It seems that there is a set of physiological factors in the plant which can be moved in one direction or the other, sometimes by hereditary changes, sometimes by environment, with similar results from the two widely differing causes.

LOSS IN DRY MATTER IN ROOTS FROM WINTER TO SPRING

While in the fall of 1924 consistent averages indicated a weight of roots of 2600 pounds per acre (Table 7), the first spring record indicated only 1430 pounds, with uniform and consistent decrease after that. Even adding the dry matter in the tops to the roots (whence it certainly came), there was an indicated loss of 900 pounds per acre of air-dry material. No single harvest in 1925 even approached the *average* of 1924, yet the plots harvested were adjoining, carefully selected, and appeared identical. While the experimental error in this work is large, the consistency of the fall

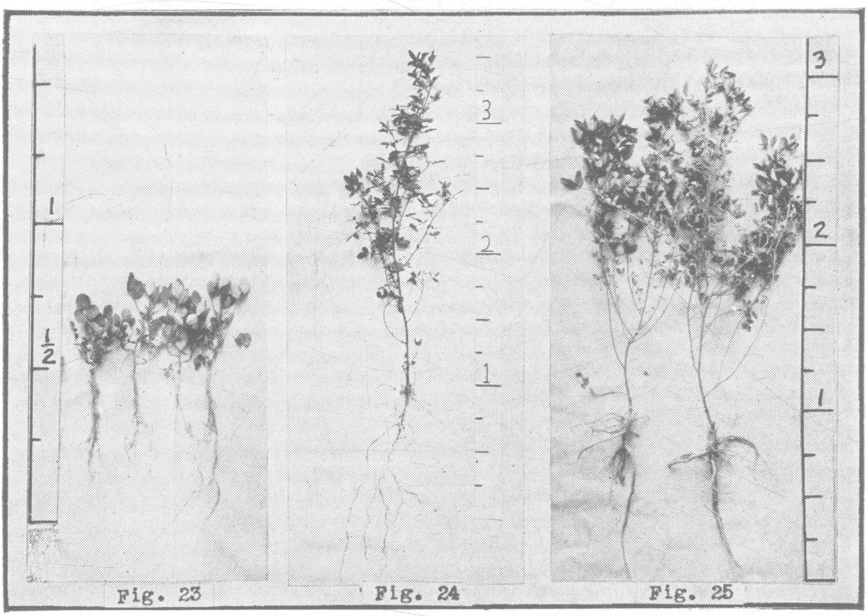

Fig. 23.—Plants of white sweet clover from Series 4, October 17, 1923, sown August 17, 1923. Contrast the root systems with those in Figure 22.

Fig. 24.—Plant of white sweet clover from Series 7, July 19, 1924, sown alone April 10, 1924.

Fig. 25.—Plants of white sweet clover from Series 3, October 13, 1923, sown in oats April 12, 1923. Note where the plants were cut by the binder, and the recovery by branching just below the cut, not from the crown.

records with themselves and the spring records with themselves is so marked that it is hard to believe that all the difference between them is due to experimental error.

Nor is this the only series showing a marked loss from fall to spring. A plot in the 1921-22 series contained 3240 pounds of roots on November 8. The following April 20, when some growth had taken place, there were 1510 pounds of roots and 1230 pounds of tops, or 2740 pounds in all. This discrepancy may be due to experimental error, but is suggestive.

The spring yields on Series 5 (Table 6) were much less than those in the fall. The April-11 sample of white sweet clover is obviously not representative, but the yellow sweet clovers showed a discrepancy in the same direction.

Differences in the weight of roots present in the fall and spring are also shown by Table 8, for the various plots and varieties of both white sweet clover and yellow sweet clover.

In Series 3 (Table 5) the roots almost certainly gained in dry matter after October 13, yet on the next April 19 neither white nor yellow sweet clover had as much dry matter in the tops and roots as in the roots only on the preceding October 13.

It thus appears that every comparison so far available between late October or early November and early the following spring shows a decided loss in dry matter over winter.

The percentage of mineral elements in the sweet clover in Series 6 is suggestive in this connection (Table 9). The percentages of potassium, calcium, and magnesium in the roots were much higher on March 26, 1925, than on November 25, 1924, and that of phosphorus was somewhat higher. The percentage of nitrogen in the roots is also rather consistently higher in the spring than in the preceding fall, tho it was not in this particular instance.

A possible explanation of all these observations is a loss of dry matter, largely carbohydrate, by respiration. This would result in an increased percentage of nitrogen and minerals in the roots. From data of Harrington (9) and of Bailey and Gurjar (4), it seems that there is still an appreciable amount of respiration at 0° C. (32° F.) and since there are many days at which the roots are at this temperature or above, a considerable loss by respiration in some winters does not seem impossible. The observation of Appleman (1) that respiration in stored potatoes is much more rapid just after refrigeration than when they are kept at a constant somewhat higher temperature, suggests that winters in which there are many alternations of temperature may cause greater losses than those of rather uniform cold.

Loss of stand by heaving has also been offered as a possible explanation of this loss, but the writer does not believe it tenable in the instances reported here, as no visible heaving took place. Further data are needed to furnish any solution of the problem.

VALUE OF HUBAM CLOVER

Mr. L. E. Thatcher and the writer published a preliminary report (33) on Hubam in January, 1922. The conclusions reached in that publication, while based on very little information compared to that now available, require surprisingly little modification at this time. All the data on Hubam secured in this investigation are collected in Table 13, with such direct comparisons with the biennial white as are available.

A study of this table shows clearly that Hubam makes on an average decidedly more top growth the first year than the biennial, but that this top growth contains a much lower percentage of nitrogen than the biennial. The biennial makes a root growth many times as large as that of Hubam, and the nitrogen content of Hubam roots is much lower than that of the biennial. In total yield of dry matter and total nitrogen per acre, Hubam is by no means equal to the biennial.

These results agree with those secured by Arny and McGinnis (2), and by other investigators generally (1, 16, 19, 21, 23, 24). The only paper giving seriously conflicting results is that of Wilkins (31).

It seemed that perhaps a mixture of Hubam and biennial might be valuable, giving more hay the first year than the biennial and more soil improvement the second than the Hubam. Plots of this mixture were sown in 1923 and 1924. The results were inconclusive, but the mixture seemed of doubtful value, largely because the Hubam and the biennial were not ready to cut for hay at the same time. However, this mixture is worthy of further trials.

Hubam dies in the fall of the year sown, and can, therefore, be plowed under for soil improvement in the fall without becoming a weed the next year, as the biennial will when fall plowed. This possible advantage is largely outweighed by the fact that there is much less nitrogen in the Hubam and that much of this will necessarily be lost by leaching before the succeeding crop can use it.

Hubam unquestionably has value as a source of honey for bees. If properly mowed, it can be kept blooming until frost, thus supplying nectar when other plants are not in bloom. However, the writer is not aware that Hubam has actually been used commercially for production of honey in Ohio.

TABLE 13.—Comparative Yields of Hubam and White Sweet Clover

Date and method of sowing	Date of harvest	No. samples averaged	Pounds per acre						Percentage of nitrogen				Pounds nitrogen per acre					
			Tops		Roots		Total		Tops		Roots		Tops		Roots		Total	
			Hubam	Bien. white	Hubam	Bien. white	Hubam	Bien. white	Hubam	Bien. white	Hubam	Bien. white	Hubam	Bien. white	Hubam	Bien. white	Hubam	Bien. white
4-2-21, in wheat	8-29-21	2	3,100	2,900	......	......	......	......	2.34	3.05	......	......	73	91	......	......	......	......
4-2-21, in wheat	9-27-21	2	3,790	3,880	260	1,890	4,050	5,770	......	......	0.76	3.18	......	......	2	60	......	......
4-6-22, in oats	9-6-22	2—6	1,420	1,560	190	1,160	1,610	2,720	2.38	3.01	.97	3.22	34	47	2	37	36	84
4-6-22, in oats	9-28-22	2—6	3,840	2,490	360	1,960	4,200	4,450	2.10*	2.77	.82	3.08	81	69	3	60	84	129
4-6-22, in oats	9-28-22	1	3,930	2,570	......	......	......	......	......	......	......	......	......	......	......	......	......	......
Volunteer, 1922	6-28-22	1	3,230	......	330	......	3,560	......	2.42	......	1.73	......	78	......	6	......	84	......
Volunteer, 1922	7-28-22	1	6,090	......	370	......	6,460	......	1.99	......	1.03	......	121	......	4	......	125	......
Volunteer, 1922	8-26-22	1	5,280	......	370	......	5,650	......	1.95	......	.98	......	103	......	4	......	107	......
4-3-22, early oats	8-25-22	3	2,730	2,090	340	1,470	3,070	3,560	2.34	3.08	1.02	2.65	64	64	3	39	67	103
4-3-22, late oats	8-25-22	3	850	1,130	130	670	980	1,800	2.34	3.08	1.02	2.65	29	35	1	18	21	53
4-3-22, wheat	8-25-22	3	2,120	850	290	500	2,410	1,350	2.34	3.08	1.02	2.65	50	26	3	13	53	39
4-7-22, alone	11-3-22	3—5	2,830	2,240	......	......	......	......	......	......	......	......	......	......	......	......	......	......
4-7-22, in oats	11-3-22	4—3	4,220	2,090	......	......	......	......	......	......	......	......	......	......	......	......	......	......
6-6-22, alone	9-8-22	1	1,280	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
4-17-23, alone	7-2-23	2	2,450	......	150	......	......	......	......	......	......	......	......	......	......	......	......	......
4-17-23, alone	7-20-23	1	2,390	......	260	......	......	......	......	......	......	......	......	......	......	......	......	......
4-17-23, alone	8-8-23	1	3.530	......	260	......	......	......	......	......	......	......	......	......	......	......	......	......
4-12-23, in oats	10-13-23	1	2,440	3,360	480	2,400	2,920	5,760	2.36	2.91	1.54	3.37	58	98	7	81	65	179
4-12-24, in oats	9-16-24	3	850	770	......	......	......	......	2.63	2.88	......	......	22	22	......	......	......	......

In conclusion, the earlier statement of Willard and Thatcher (33) may be repeated: "The present experimental data point to no very definite place that Hubam clover can fill in the ordinary farm rotations in Ohio".

VALUE OF YELLOW SWEET CLOVER

The yellow sweet clover *(Melilotus officinalis)*, tho generally considered inferior to the white, has its supporters among practical sweet clover growers. The yellow variety always produces a larger proportion of roots and usually absolutely more roots than the white in the fall of the first year. This makes the yellow definitely undesirable if it is planned to secure a hay crop from sweet clover in the fall of the first year. On the other hand, it is possible that on the average the yellow contains slightly more nitrogen early in the spring of the second year than the white. The comparisons available here are not sufficiently extensive to determine this.

In the spring the top growth of the two is nearly identical until about the first week of June. Then the yellow sweet clover comes into bloom and growth slows up so that the loss of leaves and stems exceeds the growth and the amount of material harvested decreases. The white sweet clover continues growth for two to three weeks longer, producing a final total yield for the season decidedly higher than that of the yellow. This fact is mentioned by practically all experimenters who have compared the two varieties and most of them have immediately decided that the yellow is therefore inferior to the white. This smaller yield and earlier maturity make the yellow definitely inferior to the white for pasture since the white will furnish pasture 3 to 6 weeks longer than the yellow.

The stems of the yellow average smaller than those of the white, consequently it cures into hay more rapidly than the white. Both are so inferior to other hay crops, however, that neither should regularly be used for hay the second year. The yellow ripens seed more uniformly than the white, and its shorter, smaller stems make it easier to harvest with a binder.

In chemical composition the two are very similar, there being more variation between individual samples of either species than between the two species. This is true for the mineral elements (Table 12), the fiber, nitrogen-free extract, and ether extract (Table 18), and for nitrogen in the leaves and stems separately (Table 16), as well as for nitrogen in the tops and roots (Tables 3, 4, 5, 6, and 8).

Moomaw (17) shows that yellow sweet clover is much more drouth-resistant than the white, and this may well account for the fact mentioned by McKee (15) that yellow sweet clover is rapidly replacing the white in Montana. Our experience in securing stands of the two from summer seedings during dry periods is in agreement with this, and, tho not conclusive, certainly suggests that the yellow would be superior to the white for planting in corn or indeed for any summer seeding for soil improvement.

Wilkins (32) suggests that the yellow is slightly less susceptible to acid soils than the white, a suggestion which is supported by some observations we have made in these tests. However, the difference, if any, is not great.

In depth of root system the yellow is little, if any, inferior to the white. An attempt was made May 3, 1924 to determine this quantitatively by measuring 49 roots of each taken without selection from representative areas only a few feet apart.*

TABLE 14.—Correlation Between Diameter of Roots, Depth of Roots, and Number of Stems in White and Yellow Sweet Clovers

Class	White sweet clover				Yellow sweet clover			
	No. in class	Av. No. stems	Length of roots inches	Diameter of roots inches	No. in class	Av. No. stems	Length of roots inches	Diameter of roots inches
1-5 stems	10	3.1	6.3	0.21	9	3.9	5.6	0.21
6-10 stems	23	7.9	9.4	.31	18	8.1	6.7	.26
11-15 stems	8	12.6	15.6	.41	10	12.8	9.4	.36
16-20 stems	4	17.8	17.9	.44	8	19.0	13.0	.42
21-30 stems	4	24.3	25.0	.59	4	22.8	21.3	.59
Average	49	9.8	11.7	.34	49	11.3	9.3	.32

The depths recorded are those at which the roots became approximately 1 millimeter in diameter. The diameters given were taken 1½ inches below the crown in order to avoid measuring the irregular swelling at the crown. These data are inconclusive, but suggest a slight tendency for yellow sweet clover roots to be shorter than white sweet clover roots. There is much more difference between individual plants of either than between the two species. Weaver (28) points out that it is not safe to estimate the depth to which a root extends by merely following it until it becomes small in diameter and estimating the rest. However, there is no doubt of a general correlation, in sweet clover at least, between the size of the plant and the depth to which the root extends. Table 14 is much more valuable in illustrating the correlation between the number of

*These data were secured under the writer's supervision by Mr. H. M. Linton, as part of an undergraduate minor problem in Farm Crops.

stems per plant, the diameter of the roots, and the depth of the roots, than in showing differences between the two species. Most of these stems die later, as shown in Figure 19. It is a rare mature plant that has over six stems.

VARIETIES OF WHITE AND YELLOW SWEET CLOVER

As noted in the planting plans, a few trials of other varieties of sweet clover have been included in these tests. Only one special strain of yellow sweet clover has been tested, the Albotrea strain secured from Mr. J. W. Sangster, Listowel, Ontario. This strain could not be distinguished in any way from ordinary yellow sweet clover grown beside it. The indicated yields of the Albotrea are higher, but the differences are not significant. It certainly is not inferior to the ordinary strain, however, and may be superior.

An annual mutation appeared in the plots of ordinary yellow sweet clover in 1924. A strictly annual plant with yellow flowers indistinguishable from those of the biennial was found in bloom in Series 7 on July 17. In appearance it was quite similar to *M. indica*, but was larger and later than *M. indica* usually is at Columbus, and it seems unlikely that it was of that species. One more plant was found in another sowing of seed from the same source. The plants proved to be self-sterile, at least they set no seed.

The most noticeable difference in the varieties of white sweet clover has been the time of blooming the second year. The two early strains tested, the Grundy County strain from Illinois and the Pearson from northwestern Ohio, are very similar, the Pearson being three or four days later.

The data secured are much too meagre to warrant final conclusions; but every indication, both of yield and of appearance in the field, is that the early strains are physiologically like the yellow species—that is, they produce more roots and less tops than the ordinary strain in the fall of the first year and less total yield the second year. This means that they would be equal to the ordinary strain for soil improvement by plowing under in the spring, but unsatisfactory for hay the first year or pasture the second. The Grundy County sweet clover has been extensively raised because it is easy to secure good yields of seed from it. It seems clear, however, that those who want sweet clover for anything but strictly soil improvement purposes had best avoid it.

What is most needed is a strain late enough to utilize the whole growing season of the second year. Many plants in one strain grown in 1921 were late enough to do this, as they were still producing flowers late in October. Dr. Park has made selections of some of these late strains which may prove valuable. Sweet clover is extremely variable, and by selecting desirable variations, better varieties than we have at present can be obtained.

OTHER SPECIES OF SWEET CLOVER

Thru the courtesy of Dr. A. J. Pieters of the United States Department of Agriculture, several other species of *Melilotus* were obtained and grown in short trial rows. Stands were secured of *M. segetalis, M. neopolitana, M. speciosum, M. nelcata,* and *M. suaveolens.*

M. suaveolens is a yellow biennial similar to and having no apparent advantage over *M. officinalis.* The others are small annuals of no agricultural promise.

M. indica, the annual yellow sweet clover which is known as "sour clover" in the southwest and as "King Island melilot" in Australia, has been grown from both New Zealand and southwestern seed, but is entirely worthless agriculturally in this state.

COMPARISON OF WHITE SWEET CLOVER WITH SIMILAR LEGUMES

Two fairly complete two-year comparisons between white sweet clover and three other important legumes, alfalfa, red clover, and alsike clover, were secured during this investigation, in 1922-23, and 1924-25. The years 1922-23 were unusually favorable for forage production. The fall of 1924 and the spring of 1925 were exceptionally dry and the growth of all crops was greatly reduced. Red clover and especially alsike clover suffered severely, making it difficult to secure representative square-yard samples.

The dry-weight yield of all the legumes decreased before maturity. Sweet clover in 1923 was an apparent exception but the reasons for this have already been discussed. The writer is convinced that the 1925 data show what actually takes place. Alfalfa showed the same effect until the first crop, which began to lose leaves faster than it was growing, was removed, then growth made a sharp upward turn again.

In view of the statement frequently made (22) that sweet clover starts very early in the spring, it is interesting to notice in these studies that in the first harvest of the season sweet clover almost always had a lower yield of tops than other legumes. This was conspicuous in the appearance of the field as well. In all studies made early in the season at Columbus, sweet clover was clearly very slow to start. The idea that it starts early undoubtedly is due to the tremendously rapid growth it makes after it does start.

There was little difference in the efficiency of the various legumes in producing dry matter in the second year's growth in the favorable season of 1923. Red clover and alsike clover were markedly inferior to sweet clover in the dry season of 1925. Alfalfa and sweet clover were uniform thruout.

It is commonly observed that sweet clover is a better green manure crop than red clover or alsike. On the Paulding County Experiment Farm (37) corn following a sweet clover catch crop averaged about ten bushels more per acre than following a red clover catch crop. One of the purposes of this investigation was to discover reasons for this superiority.

Sweet clover seems to have two important points of superiority over the other legumes tested, especially red and alsike. The first is in dry matter and nitrogen produced in the fall of the first year. Sweet clover is consistently more efficient in producing dry matter at this stage of its life history than any competing legume. It follows that the total dry matter in the crop plowed under early the second season is greater in sweet clover than in other legumes.

Studies in the field indicate that the physiological reason for this greater fall growth of sweet clover is that it never blooms the first year, but continues vegetative growth until stopped by freezing. Red clover and alfalfa, on the other hand, bloom the first year as soon as they have made a fair vegetative growth. This results in a practical cessation of vegetative activity for an important part of the growing season, and hence a much lower yield.

The other superiority of sweet clover is in the percentage of nitrogen present in the dry matter during April and early May (Figs. 15 and 16). The importance of this high percentage has already been discussed, but it is probably one of the factors responsible for the superiority of sweet clover for soil improvement. The other legumes vary less in the percentage of nitrogen present in their tops and roots thruout the season than does sweet clover.

Some further comparisons of sweet clover and other legumes are possible from the data of the nurse crop test (Page 72).

COMPARISONS BETWEEN OTHER LEGUMES

The comparisons between red and alsike clover from this investigation have been published (36). The few possible comparisons of red clover and mammoth clover in these tests suggest the same difference between red and mammoth clovers as between white and yellow sweet clovers—namely; in the first year the mammoth tends to put more of its dry matter into tops than the red clover, but the total production of dry matter is not far different; while in the second year the dry matter production of the two is essentially equal until the maturity of the red, when the mammoth forges ahead because it continues vegetative growth for about two weeks longer.

MISCELLANEOUS STUDIES OF SWEET CLOVER

THE DISTRIBUTION OF SWEET CLOVER ROOTS IN THE SOIL

A considerable number of rather scattered observations were made thruout this work to obtain an idea of the distribution of sweet clover roots in the soil. Lack of time and labor prevented such systematic and detailed studies as those of Weaver (28) and of Weaver, Jean, and Crist (29). The general picture of the normal development of sweet clover roots obtained in these investigations is the same as that obtained by them. If moisture is available, the roots penetrate the soil very rapidly, altho apparently not so rapidly in these soil types as in those upon which Weaver, Jean, and Crist worked in Nebraska. When sweet clover is sown in oats, however, its roots do not penetrate nearly to the depth of the oats roots by the time the oats are harvested. In Series 6 on July 17, 1924, before the oats were cut, the deepest sweet clover roots extended only 16 inches, while the oats roots extended deeper than 36 inches and were not followed farther. These plants and roots are shown in Figure 22. Observations in November 1923 showed that the roots of both white and yellow sweet clover by that time had penetrated deeper than four feet. The dry summers of 1924 and 1925 interfered with securing data on the normal penetration of the roots. Because of the excessively dry spring, the oats roots apparently dried the soil to the wilting point to a depth of at least 3½ feet. After the oats were removed the sweet clover roots could not penetrate this dry layer. The result was that this sweet clover went into the winter with a very shallow root system.

It seems that sweet clover roots normally penetrate nearly or quite to their full depth in the first year of growth. Seasonal conditions prevented our finding whether the roots penetrate deeper in the second year, but there is no reason to assume that they do not in some instances. Moisture seems to be a determining factor in their growth and distribution.

The first quantitative study of the distribution of the deeper roots of second-year sweet clover was made July 19, 1923. The top soil was quite dry, and practically no feeding roots were found in the surface foot. The soil from a depth of 15 inches to 36 inches was filled with fine roots. These rootlets were certainly securing water from this depth, and it is a fair assumption that they were also securing mineral salts from the subsoil. The total depth of the roots at this time in Series 1 was at least 5½ feet.

The spring of 1924 was one of excessive rainfall. Water was running in the tiles until late in June. Studies of root distribution in that year did not show as much development in the subsoil as in the preceding year. Sweet clover roots extended to the water table, but only slightly below it, and were abnormal when they did, being brittle and coiled in a spiral at the tip.

In 1925, despite a very dry spring and a dry fall preceding, there was not the amount of roots in the subsoil that there was in 1923. There were, however, abundant feeding roots in the lower layers.

The branches of sweet clover roots do not come out from all parts of the tap root, but in three vertical or slightly spiral rows. Nodules were found at practically all depths in these studies. While they are most abundant in the surface foot of soil, we repeatedly found them as deep as three and four feet.

The data secured in the square-yard areas harvested to a depth of 3 feet are given in Table 15.* Except in 1923 the roots in the surface part were harvested in 4-inch layers. We are so accustomed to talking of the "deep root system" of sweet clover that it is a little surprising to find from three-fifths to two-thirds of the total dry weight of the roots in the top 4 inches of soil. However, when one considers the abundant surface branching and the rapid tapering of the tap roots, which is always found in these soil types, it seems entirely reasonable. From the work of Snider and Hein (25) it is evident that in the brown silt loam of Illinois sweet clover makes a very different sort of root system.

Preliminary observations on the Wooster, Trumbull, and Clermont soils of Ohio have shown clearly that soil type has a tremendous effect on the type of root system developed, and the writer feels certain that the differences between his results and those of Snider and Hein are due to differences in the soil types. This

*The harvests of April 26, 1924 and May 31, 1924, were made under the direction of the writer by Mr. H M. Linton as part of an undergraduate minor problem in Farm Crops.

point is also emphasized in Figures 13 and 14 of the Annual Report of the Illinois Agricultural Experiment Station for 1923-24 (11), reporting the work of Bauer and Snider.

The nitrogen determinations show that the deeper roots are not so rich in nitrogen as the surface roots, a result confirmed by the more extensive observations of Snider and Hein (25). The

TABLE 15.—Distribution of Sweet Clover Roots to Three Feet

Series and date	Part harvested	Pounds per acre, air-dry	Percentage of nitrogen	Pounds nitrogen per acre
	Hay	7,320	1.52	111.3
	Stubble	1,090	1.09	11.8
July 19, 1923	Tops	8,410	1.46	123.1
Series 1,	Roots as usually harvested	1,000	1.77	17.1
	Fine roots	50	2.01	1.1
26 plants per sq. yard	Partly decayed roots	160	2.37	3.8
72 inches high	Total roots, 1 to 12 inches	1,210	1.87	22.6
	Roots 12 to 24 inches	240	1.58	3.8
	Roots 24 to 36 inches	120	1.44	1.8
	Tops	1,100	4.91	54.0
April 26, 1924	Roots 1 to 4 inches	1,060	4.28	45.4
Series 3,	Roots 4 to 8 inches	420	4.49	18.9
	Roots 8 to 12 inches	140	4.47	6.2
109 plants per sq. yard	Total roots 1 to 12 inches	1,620	4.35	70.5
4—6 inches high	Roots 12 to 24 inches	110	4.07	4.5
	Roots 24 to 36 inches	20	2.54	.5
	Hay	3,340	3.56	118.9
	Stubble	920	2.14	19.7
May 31, 1924	Tops	4,260	3.25	138.6
Series 3,	Roots 1 to 4 inches	910	2.63	23.9
	Roots 4 to 8 inches	290	2.40	7.0
134 plants per sq. yard	Roots 8 to 12 inches	70	2.27	1.6
25 inches high	Total roots, 1 to 12 inches	1,270	2.56	32.5
	Roots 12 to 24 inches	70	2.42	1.7
	Roots 24 to 36 inches	14	2.45	.3
	Hay	5,950	2.55	151.7
	Stubble	1,040	1.04	10.8
June 28, 1924	Tops	6,990	2.32	162.5
Series 3,	Roots 1 to 4 inches	680	1.99	13.5
	Roots 4 to 8 inches	210	2.31	4.8
70 plants per sq. yard	Roots 8 to 12 inches	70	2.23	1.6
60 inches high	Total roots 1 to 12 inches	960	2.07	19.9
	Roots 12 to 24 inches	60	2.30	1.4
	Roots 24 to 36 inches	20	2.45	.5
	Hay	4,560	2.48	113.1
	Stubble	1,130	1.22	13.8
June 10, 1925	Tops	5,690	2.23	126.9
Series 6,	Roots 1 to 4 inches	721	1.95	14.1
	Roots 4 to 8 inches	159	2.03	3.2
104 plants per sq. yard	Roots 8 to 12 inches	74	1.73	1.3
50 inches high	Total roots, 1 to 12 inches	954	1.95	18.6
	Roots 12 to 24 inches	96	1.64	1.6
	Roots 24 to 36 inches	34	1.93	.7
	Hay	5,710	1.83	104.5
	Dead tops	520	1.50	7.8
	Stubble	1,040	1.22	12.7
July 13, 1925	Total tops	7,270	1.72	125.0
Series 6,	Roots 1 to 4 inches	682	1.64	11.2
	Roots 4 to 8 inches	124	1.75	2.3
46 plants per sq. yard	Roots 8 to 12 inches	64	1.54	1.0
60 inches high	Total roots 1 to 12 inches	870	1.67	14.5
	Roots 12 to 24 inches	78	1.33	1.0
	Roots 24 to 36 inches	23	1.44	.3

1924 data show that stored material is moved into the tops from the roots in the second foot of soil as well as from those in the surface foot.

In making the 1923 harvest, the partially decayed roots, which are so conspicuous in all of the late harvests of sweet clover, were also saved and their amount and composition are included in Table 15. These decayed roots were ordinarily not harvested.

PROPORTION OF LEAVES AND STEMS IN THE HAY

In 1924 and 1925 a considerable number of samples were sorted into leaves and stems, in order to determine the changes in the proportion of leaves present in the hay. Nitrogen determinations were also made in a number of the samples. The determinations are of practical importance because the feeding value of the leaves is greater than that of the stems, and of physiological interest in helping to explain some of the changes in dry weight and nitrogen content previously described.

The data are given in Table 16. The proportion of leaves to stems in the fall growth after a nurse crop does not seem to change much, the leaves making up 50 to 60 percent of the hay. The data from that sown alone, Series 7, show the similarity between this comparatively mature first-year growth and the second-year growth.

In the second year there is a rapid decrease in the proportion of leaves from 50 to 60 percent on May 10 to 25 to 35 percent the latter part of June. Then the samples became rather variable. This is due to unavoidable differences in samples. "Leaves" in this table includes seeds and flowers where present. There was a great variation in the amount of seed on various stalks, and also in the rate of ripening, some plants losing their leaves and maturing seed much sooner than others.

COMPOSITION OF LEAVES, STEMS, AND SEED

In the fall the leaves and stems change very little in composition until after freezing weather. The fall leaves contain about 4 percent nitrogen and the stems slightly over 2 percent.

In the second year's growth, there is a very rapid decrease in the percentage of nitrogen in the stems and also in the leaves, but the leaves seem to reach a minimum at about 3.75 percent.

Since "leaves" includes flowers and seeds, it is quite probable that the rise in nitrogen content at the end of the season shown in 1925 was due to the increasing proportion of seed. A sample of

TABLE 16.—Percentage of Leaves in Sweet Clover Hay and of Nitrogen in the Leaves and Stems

Date	Samples averaged	Leaves in the hay	Nitrogen in	
			Leaves	Stems
	No.	Pct.	Pct.	Pct.
Series 3, white sweet clover				
October 13, 1923	1	49.6	....	....
May 10, 1924	5	61.0	....	....
May 24, 1924	6	55.8	5.38	2.46
May 31, 1924	6	47.0	5.32	2.51
June 18, 1924	5	40.6	5.21	1.82
June 30, 1924	4	28.4	4.90	1.46
July 18, 1924	4	33.2	4.11	1.48
Series 6, white sweet clover				
July 17, 1924	1	43.5	....	....
September 13, 1924	1	50.7	....	....
September 16, 1924	7	47.1	....	....
October 4, 1924	1	67.5	....	....
October 18, 1924	1	49.8	....	....
November 5, 1924	1	47.0	....	....
November 25, 1924	1	46.4	....	....
May 11, 1925	2	49.2	4.78	2.80
May 20, 1925	2	45.1	4.49	2.43
May 31, 1925	2	40.2	4.45	1.62
June 10, 1925	1	36.3	4.18	1.37
June 13, 1925	2	30.9	....	....
June 16, 1925	2	29.3	3.70	1.37
June 22, 1925	2	28.0	3.86	1.37
July 3, 1925	2	27.6	3.80	1.28
July 13, 1925	2	33.4	3.75	1.09
July 25, 1925	1	22.0	3.97	1.04
Series 7, white sweet clover sown alone				
July 23, 1924	1	45.9	....	....
September 13, 1924	1	31.1	....	....
October 23, 1924	1	32.4	....	....
Series 8, white sweet clover				
August 11, 1925	2	62.2	3.99	2.26
August 25, 1925	2	60.7	3.39	2.20
September 15, 1925	3	59.1	3.84	2.32
September 28, 1925	3	63.4	3.97	2.07
September 30, 1925	3	64.2	4.05	2.02
October 17, 1925	3	64.0	3.94	2.14
November 2, 1925	9	56.4	3.78	2.12
November 20, 1925	3	42.8	3.45	1.99
Series 3, yellow sweet clover				
June 18, 1924	3	39.9	5.29	1.85
Series 5, yellow sweet clover				
May 31, 1925	1	38.8	....	....
June 10, 1925	1	38.2	....	....
June 16, 1925	1	42.8	....	....
June 22, 1925	1	37.5	....	....
Series 7, yellow sweet clover sown alone				
May 11, 1925	1	48.1	....	....

seed in the hull from Series 6 contained 5.06 percent of nitrogen, and a sample of commercial hulled and scarified seed 5.75 percent. These percentages are amply high to raise the average percentage in the "leaves" in July, when as much as 7 percent of the total dry weight of the tops may be seed in the hull.

One mineral analysis of the leaves and stems was made, on the sample collected June 16, 1925, showing:

	Percentage present on air-dry basis			
	P.	K.	Ca.	Mg.
Leaves	0.29	1.97	1.95	0.38
Stems	.18	1.85	.55	.15

It appears that the leaves contained much larger percentages of phosphorus, calcium, and magnesium than the stems. The difference in potassium content of the leaves and stems was small, but analyses of two samples of fall hay agree with the above that the leaves usually contain slightly more:

	Percentage of potassium in	
Date harvested	Leaves	Stems
September 30, 1925	2.09	1.95
October 17, 1925	2.06	1.64

Additional data on the composition of leaves and stems are given in Table 18.

THE FEEDING VALUE OF SWEET CLOVER

The composition of sweet clover has an important bearing on its feeding value as well as its fertilizing value. The livestock raiser, however, is more accustomed to speaking of the "crude protein content" than of the "nitrogen content", and for his convenience Table 17 has been prepared. The nitrogen analyses of tops and hay from all the years have been grouped in periods of ten days to two weeks and averaged. These averages have been multiplied by 6.25 to give the average crude protein content of air-dry sweet clover hay during the period indicated.

Complete feeding-stuffs analyses were made of thirteen representative samples of sweet clover leaves, stems, and hay. Special attention was given to samples of fall-cut sweet clover, because the information on sweet clover in the feeding manuals is all for the spring crop of the second year, while the only sweet clover hay that is or should be of importance in Ohio is that cut in the fall of the first year. The data are presented in Table 18. The fiber in the leaves is remarkably low, an observation previously made by Getty

TABLE 17.—Percentage of Crude Protein in Sweet Clover Hay Averages of Samples Collected in 1923-24-25

Period	Samples averaged	Nitrogen	Protein
First year	*No.*	*Pct.*	*Pct.*
July	2	2.78	17.38
August 1—15	1	3.33	20.81
August 15—30	2	3.00	18.75
September 1—17	4	3.12	19.50
September 18—October 4	4	2.95	18.44
October 5—18	3	2.94	18.38
October 19—November 9	7	2.62	16.38
November 10—25	2	2.49	15.56
Second year			
May 10—20	5	3.36	21.00
May 21—31	6	3.00	18.75
June 1—10	7	2.70	16.88
June 11—20	5	2.32	14.50
June 21—30	5	2.22	13.88
July 1—17	10	1.91	11.94

TABLE 18.—Composition of Sweet Clover Hay

Variety	Part analyzed	Moisture Pct.	Ash Pct.	Crude protein Pct.	Fiber Pct.	Nitrogen-free extract Pct.	Ether extract Pct.
White sweet clover							
September 28, 1922	Tops	9.78	8.15	18.94	23.42	37.17	2.54
October 13, 1923	Hay	7.48	9.06	18.81	24.96	35.41	4.28
September 30, 1925	Leaves	5.22	9.43	25.31	8.55	48.58	2.91
September 30, 1925	Stems	4.23	6.26	12.63	30.57	44.33	1.98
September 30, 1925	Hay	4.86	8.29	20.77	16.43	47.07	2.58
October 17, 1925	Leaves	5.59	12.93	24.63	8.86	45.55	2.44
October 17, 1925	Stems	4.59	6.62	13.38	31.93	41.98	1.50
October 17, 1925	Hay	5.23	10.65	20.58	17.16	44.28	2.10
Av. 4 samples after nurse crop	Fall hay	6.84	9.04	19.78	20.49	40.97	2.88
May 31, 1925	Leaves	6.37	6.13	27.81	11.11	44.70	3.88
May 31, 1925	Stems	3.90	6.30	10.13	40.78	37.28	1.61
May 31, 1925	Hay	4.85	6.16	17.14	28.45	40.89	2.51
June 16, 1925	Leaves	6.28	16.00	21.81	12.33	39.68	3.90
June 16, 1925	Stems	5.11	5.47	9.00	48.16	30.62	1.64
June 16, 1925	Hay	5.45	8.56	12.75	37.66	33.28	2.30
September 25, 1925 (sown alone in spring, Clermont Co.)	Hay	6.12	7.18	17.06	32.39	34.93	2.32
Yellow sweet clover							
September 28, 1922	Tops	5.43	9.42	20.31	22.03	38.26	4.55
June 6, 1925	Hay	6.19	12.19	16.38	34.98	26.37	3.89

(8). On the basis of the average analysis the fall hay after small grain is superior to any but the very best alfalfa. The sweet clover sown alone, which had made a very rank growth, contained a percentage of fiber comparable to that in the spring growth. The rapid increase in fiber in the spring, from May 31 to June 16, would be expected from the appearance of the crop, and has been noted by Fulmer (7).

Since some are interested in the amount of green material per acre, the green weight per acre has been calculated from Tables 7 and 21. The nitrogen analyses have at the same time been calculated to percentage of protein present in the green material. These figures are presented in Table 19. The results for Series 1 and 3 are entirely similar, except that the fall growth amounted to over 11,000 pounds in 1923. Sweet clover reaches its maximum green weight some weeks before it reaches its maximum dry weight. This is true of forage crops generally, as shown by Ince (12) and Ladd (13) for corn; by Trowbridge, Haigh, and Moulton (26) for timothy; and by Willard (35) for soybeans. The fall growth is much more valuable pound for pound of green weight than the spring growth.

TABLE 19.—Amount and Composition of Green Sweet Clover Tops

Series 6	Green tops per acre	Nitrogen in green tops	Crude protein in green tops
	Lb.	*Pct.*	*Pct.*
September 13, 1924	2,500	1.14	7.13
October 18, 1924	2,000	.91	5.69
April 24, 1925	17,700	.40	2.50
May 2, 1925	24,100	.41	2.56
May 8, 1925	26,900	.42	2.63
May 16, 1925	29,800	.46	2.88
May 22, 1925	29,600	.45	2.81
May 30, 1925	29,100	.49	3.06
June 6, 1925	28,800	.51	3.19
June 13, 1925	26,400	.52	3.25
June 20, 1925	25,200	.50	3.13
June 26, 1925	26,400	.50	3.13
July 3, 1925	27,200	.51	3.19
July 11, 1925	23,600	.50	3.13
July 18, 1925	20,400	.56	3.50
July 25, 1925	19,300	.62	3.88

In connection with the feeding value of sweet clover, the high percentage of calcium present, as shown in Tables 9-12, is important, especially to dairymen. Alfalfa is the only competitor of sweet clover in calcium content of the hay or pasture.

LOSS OF NITROGEN FROM FIRST-YEAR TOPS DURING WINTER

Tables 3 to 8 show that there were from 30 to 98 pounds of nitrogen in the tops of the first year during October. If these tops are neither pastured nor cut for hay, how much of this nitrogen will remain the following spring? One set of samples was taken to answer this question. The dead tops on Plots 1 to 7, inclusive, of Series 1, which were not mowed in 1922, were carefully collected at the time of making the first spring harvest, March 31, 1923. The straw residues on these square yards were also collected separately. The indicated yields per acre and the analyses of the samples are given in Table 20.

TABLE 20.—Loss in Nitrogen from Legume Tops During the Winter

Plot	Crop	Residues per acre	Nitrogen in residues	Nitrogen per acre	Nitrogen Sept. 28	Nitrogen remaining in spring
		Lb.	*Pct.*	*Lb.*	*Lb.*	*Pct.*
1	White sweet clover	840	0.96	....	....	....
4	White sweet clover	1,310	.93	....	....	....
7	White sweet clover	1,750	.94	....	....	....
	Average	1,300	.94	12	65	18
2	Alfalfa	960	.94	9	46	20
3	Yellow sweet clover	590	1.03	6	45	13
5	Red clover	670	1.56	10	57	18
6	Alsike clover	650	1.23	8	60	13
	Average of all	....	....	....	....	16.4

This indicates that about 1\6 of the nitrogen present in the tops, on September 28 was left the following spring. Probably not all of the 5\6 was lost to the soil. Some may possibly have been translocated to the roots, and some in the leaves and fine stems which fall to the ground may have been leached into and not entirely leached out of the soil. It would require lysimeter experiments to secure complete data on the loss of nitrogen during this period. Such experiments would also give valuable information on what happens to the nitrogen lost from the leaves, stems, and roots which die during May and June.

The oats stubble left on the surface of these plots March 31 averaged 700 pounds per acre, and contained 0.48 percent of nitrogen.

RATIO OF AIR-DRY TO GREEN WEIGHT

Green weights were not systematically taken during this investigation. Some attempt was made at first to take green weights of the square-yard samples but this did not prove to be feasible, because the tops dried out during the necessarily slow process of digging the roots. In 1924 and 1925 a special series of samples was taken to determine the ratio of air-dry to green weight. Most of these were samples of 1 to 2 kilos green weight, tho a few were smaller. The data from this series of samples and a few observations on the fall growth are given in Table 21. Some observations on the ratio of dry weight to green weight in the roots are also included. Taking the green weight of roots was discontinued in June because the roots dried out considerably before the weights could be taken.

The tops showed the rapid increase in the percentage of dry matter in the green plant, which is characteristic of all plants as they become more mature. Some May samples of sweet clover contained less than 10 percent of dry matter in the fresh green material. This is of practical importance because of the large proportion of water to be removed in making sweet clover hay, or even satisfactory silage (6, 18).

TABLE 21.—White Sweet Clover Hay and Roots, Percentage of Dry to Green Weights

Ratio of air-dry weight of hay to green weight			Ratio of air-dry weight of roots to green weight		
Series and date	Samples averaged	Air-dry weight	Series and date	Samples averaged	Air-dry weight
Series 3	*No.*	*Pct.*			
September 13, 1923	5	31.4			
October 13, 1923	1	29.4			
May 10, 1924	5	11.9			
May 24, 1924	6	13.4			
May 31, 1924	6	13.7			
June 18, 1924	3	14.7			
June 30, 1924	4	24.0			
July 18, 1924	6	28.9			
Series 6			Series 6	*No.*	*Pct.*
September 16, 1924	8	35.4	September 13, 1924	1	31.1
May 11, 1925	2	13.4	March 26, 1925	4	20.4
May 20, 1925	2	15.1	April 3, 1925	4	19.9
May 31, 1925	2	18.3	April 10, 1925	4	16.5
June 2, 1925	2	16.8	April 17, 1925	4	15.6
June 10, 1925	3	22.8	April 24, 1925	4	14.0
June 13, 1925	2	21.2	May 2, 1925	4	15.2
June 15, 1925	4	26.3	May 8, 1925	4	15.0
June 22, 1925	4	27.5	May 16, 1925	4	15.5
July 3, 1925	2	27.1	May 22, 1925	4	15.4
July 13, 1925	3	29.3	May 30, 1925	4	17.3
July 25, 1925	1	37.1			
Series 8					
September 28, 1925	4	28.1			
October 31, 1925	1	29.7			

The ratio of dry to green weight in the roots indicates that the dry-matter content of the roots decreased as the season advanced. This observation raises some physiological questions, which are worthy of separate investigation. It may be noted that one would receive an entirely false impression of the development of sweet clover roots by taking green weights only, beginning in the early spring. While the roots were actually losing nearly half their dry matter, the green weights might change very little.

EFFECT OF NURSE CROPS ON SWEET CLOVER

An experiment to determine the effect of different nurse crops on the legumes seeded in them was started in 1921. As its most important results were secured in connection with sweet clover study, it was merged with the sweet clover project when the latter was started.

The plan was to sow strips of red clover, alsike clover, alfalfa, white sweet clover, and yellow sweet clover across the departmental variety test plots of winter wheat and of spring grains. The spring-grain series included spring wheat and one to several varieties of barley.

Seedings on this general plan were made in the years 1921, 1922, 1923, and 1924. The legumes, especially the sweet clover, interfered so seriously with the accuracy of the variety trials and with the rotation that the project was discontinued in 1925. The legumes were sown from the grass seed attachment of the grain drill. The oats and wheat series were sown at the same time, immediately after completing oats sowing.

No definite results were secured in 1921. The stands were somewhat uneven, but generally satisfactory in all the nurse crops. There was no possible correlation of the irregular variations in stand with the different nurse crops.

In 1922 there were very definite differences in the stand of sweet clover secured in the several nurse crops. Unfortunately, while the other legumes were sown March 25, the biennial sweet clovers were not sown until April 3. They were sown on the same date in the oats series and in the wheat series, so that the differences between the nurse crops cannot be attributed to the date of seeding; but the fact that Hubam, which was included this year and sown a week sooner, made a fair stand in the wheat, raises the question as to what the others would have done if sown earlier.

The two biennial sweet clovers were nearly a total failure in the wheat. There was also a great difference between the sweet clover sown in early oats and that sown in late oats. Because of their possible value in this investigation, three square-yard samples were harvested in each crop in each of the nurse crops, on August 25, 1922, Table 22. This table shows clearly the great superiority of early oats over late oats and wheat in this season and on this soil type (Brookston silty clay loam) when the clovers were sown at the same time in all the crops. No samples were harvested following barley and spring wheat, but there was no observable difference between these plots and those following early oats. Nitrogen was determined in one sample of each of the sweet clovers with the following results:

Crop	Percentage of nitrogen in		Pounds of nitrogen per acre after early oats		
	Tops	Roots	Tops	Roots	Total
White sweet clover	3.08	2.65	64	39	103
Yellow sweet clover	2.95	2.93	51	72	123
Hubam sweet clover	2.34	1.02	64	3	67

This accumulation of nitrogen is rather surprising for so early in the season. The oats range was plowed as soon as these harvests were made, and later sown to winter wheat. The excess of nitrogen present was sufficient to cause the wheat to lodge badly the next season. Altho the sweet clover was plowed a month before the wheat was seeded, considerable of it came up in the wheat the next year.

TABLE 22.—Yields of Legumes Sown in Early Oats, Late Oats, and Wheat. Harvested August 25, 1922

Crop	Nurse crop	Air-dry weight per acre			Plants per square yard
		Tops	Roots	Total	
		Lb.	*Lb.*	*Lb.*	*No.*
White sweet clover	Early oats	2090	1470	3560	151
White sweet clover	Late oats	1130	670	1800	136
White sweet clover	Wheat	850	500	1350	65
Yellow sweet clover	Early oats	1730	2460	4190	197
Yellow sweet clover	Late oats	1190	1300	2490	133
Yellow sweet clover	Wheat	230	300	530	41
Hubam clover	Early oats	2730	340	3070	138
Hubam clover	Late oats	850	130	980	95
Hubam clover	Wheat	2120	290	2410	97
Red clover	Early oats	2130	610	2740	246
Red clover	Late oats	1580	480	2060	187
Red clover	Wheat	950	240	1190	134
Alsike clover	Early oats	1730	580	2310	165
Alsike clover	Late oats	1010	340	1350	75
Alsike clover	Wheat	1190	450	1640	236
Alfalfa	Early oats	1370	920	2290	234
Alfalfa	Late oats	760	390	1150	120
Alfalfa	Wheat	760	720	1480	222

The test in 1923 was carried out on new plots on another tract and resulted in irregularities in the stand, which bore no relation to the nurse crop used. However, the stands in oats seemed generally better than those in wheat.

In 1924 good stands were secured in all nurse crops, because of the moist, favorable season. In the spring-grain series the sweet clover grew so well as to be a nuisance, especially in some of the weaker barley varieties. The final stands in the spring grains appeared better than those in wheat, even in this year, tho this was not borne out by counts.

There were almost no rains after the small grains were cut until winter. This resulted, as in 1922, in a much better growth following the early oats than following the late oats. The stands, as determined by counts, were not materially different.

The general observation from this series of tests is that on these soil types sowing in spring grain is a surer method of obtaining a stand of sweet clover than sowing in wheat, altho good stands can usually be secured in wheat. Either early oats or barley is much superior to late oats as a nurse crop for sweet clover. There is little choice between barley and an early oat, such as Fulghum, as a nurse crop. Probably the general belief that barley is superior to oats as a nurse crop is due to comparisons between barley and medium or late oats. These observations apply to alfalfa as well as sweet clover.

Just why wheat as a nurse crop has not given as good results here as it has in other sections of the State is not clear, but the writer believes that one important factor is the covering of the seed. This soil is not loose enough to cover sweet clover seed well even when it is sown with a disc drill, if the spring is not unusually moist. If sweet clover is to be sown in wheat in late March or early April, special pains should be taken to insure that it is covered. Farm observations would also suggest that sweet clover in wheat should be sown early.

THE RELATION OF STAND TO YIELD

There is little definite information on the relation of stand to yield of forage crops. Ordinarily forage crops are sown thick enough to permit the large majority of the plants produced to be killed by competition. Keeping the stand constantly crowded in this way at least tends to crowd out weeds. From a study of these experiments it seems that there is a relation between stand and yield but that it is very slight, and that the value of stand-counts in forage crop experiments, except as a measure of extreme conditions, is correspondingly slight.

SUMMARY AND CONCLUSIONS

1. This paper reports four years of experiments with sweet clover on Miami silt loam and Brookston silty clay loam.

2. Yields of tops and roots were secured from carefully selected square-yard samples, replicated as often as feasible.

3. Careful selection of a series of apparently uniform small plots after the crop is established is a valuable means of reducing experimental error where yields at different dates or following different later treatments are desired. This method makes possible the utilization of soil otherwise too ununiform for experimentation and of samples otherwise too small to be trustworthy.

4. The probable error of a single yield determination in these experiments, as determined from 54 averages of 2, 3, and 4 harvests on the same date, 178 harvests in all, is ± 11.5 percent of the yield for the tops and ± 11.3 percent of the yield for the roots.

5. The probable error of a single nitrogen determination, as calculated from 34 pairs of samples of tops and 39 pairs of samples of roots, collected on the same day, is ± 0.13 percent for the tops and ± 0.10 percent for the roots.

6. Differences in some instances, of more than 50 percent of the smaller amount present were found in the percentages of mineral elements present in sweet clover harvested the same day in the same field.

9. Sweet clover samples taken from light colored soil (Miami) and dark colored soil (Brookston) did not show any consistent difference in nitrogen content, either in tops or roots.

8. The crown buds do not ordinarily develop shoots the first year. In the fall of 1924 a small percentage of crown buds formed shoots the first year. This did not cause winter-killing.

9. Sweet clover came up the next year even when plowed under as early as August 28.

10. Biennial sweet clover at Columbus has not bloomed the year it was seeded.

11. Unless the stand is abnormally thick or the season abnormally dry, there is little change in the stand during the first year. In the second year the plants begin to die very rapidly about the 10th of May, or later in a moist or late season. This thinning out of the stand continues until maturity, when the final stand contains about 30 plants per square yard, regardless of the number of plants in the original stand.

12. The weight of tops in the first year's growth reaches its maximum about October 1.

13. In the first year's growth, comparatively little material is stored in the roots until August. Storage in the roots is most rapid in October, the weight of roots usually doubling from October 1 to freezing weather.

14. In the second year, sweet clover tops increase in weight at a rapid rate. The development of stands in which only a small amount of root storage took place the preceding year is parallel to but later than that in which greater storage occurred. The final air-dry weights of tops are nearly uniform, regardless of the time and method of seeding the preceding year.

15. In the second year, the weight of roots decreased rapidly at first, then more slowly until a weight of about 900 pounds per acre was reached. If the weight of roots at the beginning of the season was less than this, the roots sometimes increased in weight.

16. The effect of cutting sweet clover for hay in September of the first year is to reduce the storage in the roots, and so the amount of material available for plowing under early the following year, to about half that available when the clover is not cut.

17. The season of 1924 was much later than 1923 and 1925. This was evident in field observations and is shown in the dry weight produced, percentage of nitrogen, total nitrogen per acre, number of plants per square yard, and the percentage of leaves in the hay.

18. In the second year, the average weight of tops per plant increased steadily. The average weight of roots per plant decreased until about May 10, then increased slowly until the end of the season.

19. The percentage of nitrogen in the roots increases slowly from July to November of the first year. That in the tops remains nearly stationary at about 3 percent until the tops are partially killed by freezing.

20. In the second year the percentage of nitrogen in the roots decreases rapidly from about 4.5 percent to less than 2 percent. The more material stored in the roots the first year, the less rapid the decrease in percentage of nitrogen the second year.

21. The percentage of nitrogen in the tops also decreases rapidly in the second year.

22. The total nitrogen per acre contained in the second year's growth usually reaches a maximum before the middle of June. The larger the first year's growth, the earlier this maximum is reached.

23. The best time to plow under sweet clover for soil improvement is April 20 to May 10 of the year after seeding. Plowing it at this time has the following important advantages:

a. The sweet clover is killed without difficulty.

b. A corn crop following can be planted early enough to secure maximum yields.

c. Plowing at this time secures 80 percent of the maximum amount of nitrogen accumulated during the season, as indicated by the average of four years' experiments.

d. The percentage of nitrogen in the dry matter is high enough so that in its decomposition a large surplus of nitrogen is available for the succeeding crop.

e. The reserve moisture stored in the soil is not exhausted by the continued growth of the sweet clover.

This conclusion may be modified when for any reason a poor growth is secured the first year.

24. In first-year white sweet clover tops from July 17 to November 25:

a. The percentage of phosphorus decreased from 0.24 to 0.14.

b. The percentage of potassium was 3.27 on July 17, and decreased sharply to about 1.80 on and after September 13.

c. The percentage of calcium increased from 1 to a maximum of nearly 2 on October 17, then slowly dropped again.

d. The percentage of magnesium ranged from .25 to .38, being practically constant at the latter figure after September 13.

25. In first-year white sweet clover roots from September 13 to November 25:

a. The percentage of phosphorus was nearly constant at about 0.26, which is higher than in the tops.

b. The percentage of potassium decreased fairly regularly from nearly 1.00 to less than 0.75.

c. The percentage of calcium was nearly stationary at about 0.20.

d. The percentage of magnesium increased regularly from 0.03 to 0.15.

26. In second-year white sweet clover tops from March 26 to July 25:

a. The percentage of phosphorus slowly decreased from 0.35-0.50 to 0.15-0.20.

b. The percentage of potassium remained nearly constant at about 2.00.

c. The percentage of calcium rose sharply for the first four or five weeks of the growing season from less than 1.00 to 1.50 or nearly 2.50, then decreased steadily to less than 1.00 again.

d. The percentage of magnesium decreased from a maximum of 0.50-0.75 to 0.15-0.25.

27. In second-year white sweet clover roots from March 26 to July 25:

a. The percentage of phosphorus slowly decreased from about 0.40 to 0.20-0.25.

b. The percentage of potassium increased rapidly from about 1.00 to 1.50 or 2.00 about June 1, then slowly decreased again.

c. The percentage of calcium increased slowly from about 0.30 to about 0.60.

d. The percentage of magnesium increased slightly. In 1925 the percentage of magnesium was nearly the same as that of calcium; in 1924 it ranged from 0.18 to 0.39.

28. The maximum total amounts per acre of the various mineral elements found in white sweet clover (July 17, 1924, omitted for reasons discussed on page 44) were the following:

Phosphorus, 21.4 pounds on June 28, 1924.

Potassium, 169 pounds on June 27, 1925.

Calcium, 80 pounds on June 28, 1924.

Magnesium, 24 pounds on May 30, 1925.

29. Summer seedings of sweet clover did not produce a very large amount of nitrogen or organic matter to plow under early in May of the second year, but the final yield in July was not greatly different from that of the series sown in the preceding spring.

30. When sown in the summer in a somewhat dry soil, alfalfa proved more likely to make a stand than sweet clover..

31. Summer-sown sweet clover heaves badly on many soils—more so than any other legume. Sweet clover is not killed by heaving, unless the plant is lifted nearly out of the ground, and frequently recovers and makes a fair yield even after being severely heaved. Practically no trouble has been experienced at Columbus from the heaving of spring sown sweet clover.

32. The percentage of tops in the total air-dry weight is 80 to 90 in July of the first year, regardless of the total growth made by that time. The percentage of tops then decreases steadily until by winter it is always below 50 and sometimes as low as 20. When sown in the summer, the percentage of tops in the total weight after two months growth was about 60. It is, therefore, summer-

sown and not spring-sown sweet clover which makes a large root growth in proportion to the tops during its first few weeks of growth.

33. In the second year the percentage of tops in the total dry weight increases abruptly to somewhat over 90 in July. That these changes are controlled by factors in the external environment is evidenced by the fact that both seedlings and old plants respond similarly in respect to root-top ratios.

34. There appeared to be a considerable loss in dry matter in the roots from November to the following March. This may have been due to respiration.

35. Hubam, the annual variety of white sweet clover, produces considerably more hay in small grain stubble than the biennial, but the hay is coarse and stemmy. Eight samples of Hubam hay averaged 2.30 percent of nitrogen, or 14.4 percent crude protein, while the fall growth biennial white sweet clover hay averaged more than 19 percent protein.

36. The average yield of 22 samples of Hubam roots collected at different stages of growth was 270 pounds per acre, while the maximum was 480 pounds. The nitrogen content of these roots, as an average of 8 samples, was only 1.10 percent. Hubam is far inferior to the biennial sweet clover for soil improvement.

37. No important place for Hubam in Ohio rotations is shown by these experiments.

38. The biennial yellow sweet clover differs from the white in the following respects:

a. It has a much higher proportion of roots in the fall growth of the first year than the white, and usually produces a greater weight of roots at this time than the white.

b. It blooms about ten days earlier than the white in the spring of the second year and its blooming period is much shorter.

c. It produces a much smaller total yield for the season.

d. It has smaller, shorter stems than the white and so cures more rapidly into hay and is more readily harvested for seed.

e. It seems to be much more likely than white sweet clover to produce a stand when sown in rather dry soil in the summer, and is therefore recommended for sowing in corn or for any other summer seeding.

39. The yellow sweet clover does not greatly differ from the white in total dry weight or total nitrogen produced before June 1 of the second year, in composition of leaves, stems, tops, or roots, or in depth of roots.

40. Yellow sweet clover, therefore, is not recommended where a fall cutting of hay is desired, or for pasture the second year. It is equal to the white for soil improvement in May, and superior to the white for summer seedings, for second year hay, and as a seed producer.

41. Grundy County and other small early strains of white sweet clover are similar to yellow sweet clover in that they are valuable for soil improvement and seed production, but should not be sown when hay is wanted the first year or pasture the second.

42. No other species of sweet clover proved to have any agricultural value in Ohio. An annual yellow mutation, similar to Hubam, appeared in one culture of yellow sweet clover, but did not form seed.

43. Sweet clover produced more dry matter and nitrogen in the fall of the first year, and had a much higher percentage of nitrogen in the dry matter early in the second year, than the other legumes studied.

44. The reason that sweet clover produces more growth in the fall of the first year than other legumes seems to be that it continues uninterrupted vegetative growth until freezing weather, while alfalfa and red clover usually bloom and form seed the first year after they have made a fair vegetative growth, thus reducing the vegetative period and the yield.

45. Sweet clover starts into growth later in the spring than alfalfa, red clover, or alsike clover.

46. Sweet clover roots made their greatest growth in depth in the first year. In the second year feeding roots were abundant in the second and third feet of soil, and often deeper. Nodules were found at all depths.

47. On these soil types, from ⅗ to ⅔ of the total weight of sweet clover roots was in the top four inches of soil.

48. The deeper roots were usually lower in percentage of nitrogen than those in the first foot of soil.

49. The percentage of leaves in sweet clover hay is 50-60 in the fall of the first year. In the second year it drops rapidly from 50-60 to 25-35.

50. Sweet clover leaves in the fall growth contained almost 4 percent of nitrogen and the stems about 2 percent. In the spring growth the leaves varied in nitrogen content from 5.38 percent to 3.75 percent, and the stems from 2.80 percent to 1.04 percent.

51. Sweet clover seed in the hull contained 5.06 percent of nitrogen and 5.75 percent when free from hulls.

52. In one sample of sweet clover, the leaves contained more than three times as much calcium, more than twice as much magnesium, half again as much phosphorus, and slightly more potassium than the stems.

53. Sweet clover leaves from the first-year hay contained 8.70 percent fiber, and from second-year hay 11.72 percent fiber. The first-year stems contained about 30 percent fiber, while second-year stems increased rapidly in percentage of fiber as the season advanced, containing 48 percent on June 19, 1925.

54. The percentage of crude protein in first-year sweet clover hay in August and September varied from 18.40 to 20.81, averaging over 19 percent.

55. Sweet clover hay contained a high percentage of total ash, some samples ranging as high as 15 or 16 percent. The average of 27 samples of white sweet clover hay and tops at all stages of growth was 9.76 percent ash.

56. About one-sixth of the nitrogen present in sweet clover tops in the fall remained in the weathered stems the following spring.

57. The air-dry weight of sweet clover hay was about 30 percent of the green weight in the fall of the first year. In the spring of the second year, the percentage ranged from about 12 early in May to 30 and above late in July.

58. The percentage of dry matter in the fresh roots of sweet clover decreased very considerably from March to May of the second year.

59. In general, spring grains have been more satisfactory than wheat as nurse crops for sweet clover on these soil types. Early oats, such as Fulghum and Sixty Day, and barley were superior to late oats in stand secured and especially in the growth made by the sweet clover in the fall of the first year.

60. Sweet clover should not be sown alone in the spring, unless it is known from previous experience that weeds will not smother it.

61. With weed competition eliminated, sweet clover sown alone made large yields of dry matter the first year, amounting to 5 tons per acre in one experiment.

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